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RENEWABLE ENERGY TECHNOLOGIES

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT

OF THE

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

ONE HUNDREDTH CONGRESS

FIRST SESSSION

ON THE

CURRENT STATUS OF THE RENEWABLE ENERGY TECHNOLOGIES IN OUR NATIONAL ENERGY POLICY—FISCAL YEARS 1988-89

MARCH 24 AND 26, 1987

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RENEWABLE ENERGY TECHNOLOGIES

TUESDAY, MARCH 24, 1987

U.S. Senate,
Subcommittee on Energy Research and Development,
Committee on Energy and Natural Resources,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:30 p.m., in room SD-366, Dirksen Senate Office Building, Hon. Wendell H. Ford, presiding.

OPENING STATEMENT OF HON. WENDELL H. FORD, A U.S. SENATOR FROM THE STATE OF KENTUCKY

Senator Ford. Today the Subcommittee on Energy Research and Development is holding the first of a series of hearings on the policy for energy research and development in the United States.

The two hearings this week will concentrate on renewable energy research and development. We will hear testimony on solar, wind and ocean thermal techniques for each production, and on Thursday there will also be testimony on energy conservation, research and development.

In April we will hold hearings on research and development for clean coal technologies.

I want to congratulate Senator Fowler, the Vice Chairman of the Subcommittee, for his efforts in encouraging us to hold these hearings on renewable energy, and in taking the lead in organizing them.

In a minute I will turn the hearing over to him to chair. I know the Subcommittee will be in capable hands.

In the past several years we have not been giving the kind of attention to renewable energy R&D that we should. These are emerging energy sources. They are not as important in the energy mix today as they will be in the future. They are not as important in energy mix today as they should be.

I hope we can get some advice in this hearing and on Thursday about how to do better in our efforts to develop renewable energy technologies. We have stiff competition from overseas, particularly from Japan.

If we do the job right we will have additional energy sources to make use of and in improvement in our international competition. Those are our goals and they are goals worth working for.

So, it is my pleasure at this time to turn the hearing over to Senator Fowler, and I am sure that what he learns from the hearing today, and the other one this week, will be important to us as this

Committee moves on into the future. So, Senator, I am delighted to turn the Chair over to you.

STATEMENT OF HON. WYCHE FOWLER, JR., A U.S. SENATOR FROM THE STATE OF GEORGIA

Senator **Fowler** [presiding]. I do want to thank the chairman for his leadership efforts on behalf of developing a comprehensive energy policy for our country and for his permission and help in allowing us to conduct these two days of hearings on renewable energy.

I welcome everybody here for the first of the two hearings on Renewable Energy Policy in the 100th Congress. We have a diverse witness list. I know we are going to learn from these witnesses.

The purpose of this hearing and the one on Thursday is simply to learn about renewable energy policy—its possibilties, its techniques, and its opportunities. We want to know about the status of renewable energy in the United States. We want to know what we can do to improve that status.

I would like to call everyone's attention to the exhibits at the back of the room. I hope these exhibits will be like the proverbial picture that's worth a thousand words in that we can see already what it is we'll be talking about.

We also have available today a very helpful report that is available in at the back of the room, prepared by the Congressional Research Service, entitled "Renewable Energy Technology: A Review of Legislation, Research and Trade." This report provides an excellent background for these hearings.

Two reasons why we ought to be concerned about the status of renewable energy. First, renewable energy technologies are an important and growing part of world trade. We use to be a leader in this trade—an example is one sale of photovoltaic devices and wind machines—but that lead has been lost.

By 1991, the world market in wind machines, photovoltaics and solar thermal energy conversion will be worth over $2 billion per year. With the technological potential we possess, the United States ought to be, it seems to me, challenging these sales.

We want to find out how to do that. We want to find out what role research and development can play in recapturing the lead we once had in renewable energy technology. We also want to find out what mistakes we have made so we will not make them again.

Second, we ought to be concerned about renewable energy because we do not now have a reliable energy supply. We have relatively low prices and apparently plentiful supplies of energy at this moment, but that again looks like we have been lulled into complacency.

The fact is, this nation faces an almost certain increase in oil imports over the next several years. The Administration estimates that import levels will reach 8 to 10 million barrels per day in the 1990's. At that rate, imported oil will make up 60 percent of our total oil demand. By comparison, we were dependent on imports for 35 percent of our oil at the time of the Arab oil embargo.

Reversing the trend of rising oil imports is an essential part of national policy. To do this we have to develop every secure, affordable, and clean energy source we can find. We have to develop renewable energy technology.

In past years this Committee has strongly supported sensible programs in the development of renewables. These were times of great pressure on the federal budget. We all know everyone has to do better with less. We know that, but we have to do better.

I welcome all of our witnesses. We are going to begin this afternoon with the representatives from the Administration, and we are very pleased to have Donna Fitzpatrick, Assistant Secretary for Conservation and Renewable Energy Programs, U.S. Department of Energy.

Secretary Fitzpatrick, we are delighted to have you here, as well as members of your staff whom you may introduce whenever you deem appropriate. I have read your statement, and it will, of course, be submitted for the record in its entirety. If you could abbreviate that statement so that we can have some time for questions and discussion, that would be helpful for all concerned.

STATEMENT OF DONNA R. FITZPATRICK, ASSISTANT SECRETARY, CONSERVATION AND RENEWABLE ENERGY, DEPARTMENT OF ENERGY, ACCOMPANIED BY DR. JOHN BERG, PRINCIPAL DEPUTY ASSISTANT SECRETARY, AND DR. ROBERT SAN MARTIN, DEPUTY ASSISTANT SECRETARY FOR RENEWABLE ENERGY

Miss **Fitzpatrick**. I would be happy to do that, Mr. Chairman. I do have with me today Dr. John Berg on my left, who is the principal Deputy Assistant Secretary, and on my right, Dr. Robert San Martin who is the Deputy Assistant Secretary for Renewable Energy.

Senator **Fowler**. Welcome.

Miss **Fitzpatrick**. Thank you. I will very briefly summarize the full statement.

I appreciate the opportunity to appear before the Subcommittee today to discuss the National Renewable Energy Policy and the status of the Department's Renewable Energy programs. The policy and the budget for these programs are consistent with and support the goals and objectives of our national energy policy, and they are also fully responsive to the administration and congressional goals of deficit reduction.

In allocating our resources we are concentrating on applying federal funds only where they are most effective, and supporting research and development efforts where the potential payoff is high but which private industry cannot be expected to pursue because the results are difficult to attain, or because the return on investment would require an exceptionally long time to be realized.

Within the current federal budget limitations we will concentrate our efforts on the highest priority research in order to address the most critical, sensitive, and technological issues. Efforts will also continue to focus on improved dissemination of the results of our R&D programs, and on expanding collaboration with the private sector.

Renewable energy encompasses several significant areas of technology which are already making substantial contributions to our nation's energy economy, and they should contribute even more in the future, especially if the research that we are pursuing proves successful.

Renewable energy currently provides almost six quads or 8.7 percent of U.S. energy production. This is a contribution which we expect could grow to 12 and a half quads by the year 2010, which would represent approximately 15 percent of the nation's energy supply at that time.

In a sense, industry is waiting for the demand to develop. We currently have an overcapacity situation with regard to electricity generation in this country, which has reduced demand for new power plants of any type.

The adoption of new technologies such as renewables in the marketplace depends not only on their being competitive but also on there being demand for new capacity. Our goal is to solve the fundamental scientific and technical problems so that renewable technologies will be ready to compete successfully on their own merits when demand for new capacity inevitably occurs.

In fact, renewable energy research has made remarkable progress over the last several years, resulting in cost reductions in some technologies by as much as a factor of ten double lifetimes and 400 percent improvement in efficiencies.

Even with this progress, the remaining challenges are significant. Development of an adequate technology base upon which industry can build competitive renewable energy systems will require continued government and private sector research well into the 1990's. The progress of research, technology applications, and the response of the American people to market forces provide the basis for our optimism concerning the role of these technologies in our future energy supply mix.

Mr. Chairman, we are pleased to have the advice that we have received from the Subcommittee and from Congress, and we thank you for the opportunity to appear here today. We are prepared to answer your questions.

[The prepared statement of Miss Fitzpatrick follows:]

STATEMENT OF

DONNA R. FITZPATRICK

ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY

U.S. DEPARTMENT OF ENERGY

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES

SUBCOMMITTEE ON ENERGY RESEARCH & DEVELOPMENT

U.S. SENATE

MARCH 24, 1987

Mr. Chairman and Distinguished Members of the Committee:
It is a great pleasure to be with you today to discuss national renewable energy policy and the status of renewable energy technologies. An understanding of these policy and status factors underlies the Department of Energy FY 1988 budget request of $101.1 million.

The nation's overall national energy program is premised on broad policy goals -- improving national energy security and fostering an adequate, stable supply of energy at reasonable cost, while protecting public health and safety and environmental quality. The reliability of an adequate supply of energy impacts day-to-day functions of the entire economy as well as the operation of the defense infrastructure. Because energy is an input to virtually all production processes, it can influence the competitiveness of the country's goods and services in domestic and foreign markets.

Rising U.S. oil imports are creating concerns in the public and private sectors. These concerns emphasize the need to continue development of new, domestic sources of energy. However, the short- to mid-term outlook for relatively stable oil prices can have conflicting effects on the development and integration of new energy technologies into the Nation's energy supply. While this situation provides a window of opportunity for long-term development of competitive energy technology alternatives, it also establishes challenging performance and delivered energy cost requirements.

Over the long-term, renewable energy technologies can contribute to the achievement of our policy goals. Technology progress can complement and extend competition in the energy market. Technological progress can support improved efficiency, increased resource recovery and development of substitution options, and permit use of formerly unusable resources. It is the potential of U.S. scientific and engineering capabilities which provide optimism for the long-term development of renewable energy. The diversity of the renewable energy resources encourages the development and application of a family of technologies that will collectively reduce the risk that supply interruptions or price increases in conventional energy sources will adversely impact economic growth and security. The flexibility of renewable energy technologies allows direct matching of end-use energy requirements for heat, light, electricity, or fuels. The technologies have applications across economic sectors: residential, commercial, industrial, transportation, and utility. Renewable energy systems also offer flexibility in system size and capacity. To the extent that they are competitive, the modularity of renewable energy technologies will allow energy generation and production equipment additions to be made in smaller units than is common for conventional technologies, an advantage when energy demand projections are uncertain. Shorter lead times for adding these increments reduce uncertainties in planning and allow capital outlays to be made over shorter periods of time, reducing financial risk.

Renewable energy technologies, primarily hydropower and wood burning, currently make a noticeable contribution to U.S. and world energy supplies, a share that is approaching 9% of all energy consumed. Future renewable energy supply growth is expected to be concentrated in the emerging technologies that are the focus of our research activities. Aside from hydroelectric systems, renewable energy technologies have not yet realized their potential for providing the advantages they can offer in the competitive marketplace. Research performed to date has solved many technical problems, uncertainties have been reduced, and a solid technical base for future research has been established. This research has allowed scientists to establish specific technical and performance goals that are required to achieve economic viability. Continued long-term research is being undertaken to address the fundamental scientific and technical issues which hinder achievement of these goals.

Research results of the past decade have already yielded cost reductions by as much as a factor of 10, doubled lifetimes, and resulted in 400% improvements in efficiency. Even with this progress, the remaining challenges are significant. The development of an adequate technology base upon which industry can build will require research over the long-term. Research-driven technological developments over the coming years will play a critical role in determining the competitive status of renewable energy options in the marketplace and, therefore, the degree to which the technologies' potential can be realized.

Federal research funds are generally concentrated in basic and applied research and development, and on the scientific and engineering research necessary for a better understanding of basic resource and technology pheromena, methods to use these resources for producing competitive and useful forms of energy, and important crosscutting technologies for storage of energy and for reliable and efficient management of the electric energy supply network. Our efforts are focused on the highest priority research to address the most critical technology base issues. The focus of such efforts will be on those technologies with the greatest long-term promise for contribution to the Nation's energy supply mix.

Current Department of Energy conservation and renewable energy research activities can be grouped into three principal categories: materials, systems, and testing and evaluation. A responsive, interactive relationship exists among these three areas, each providing an effective feedback mechanism for the direction of research in the others. As can be seen by a brief review of the funding request for each technology, research activities in each technology area encompass all three of these research types, though the emphasis varies across the programs.

SOLAR BUILDINGS

Research has confirmed that significant increases in the supply of solar energy to buildings can be obtained through emerging developments in such fields as electrochemistry, holography, optical physics, and advanced materials. For example, current research indicates that application of these developments to such solar technologies as switchable glazings, commonly referred to as "smart windows", and advanced phase change thermal storage wallboard materials could potentially double the present solar energy contribution to building heating energy requirements. The FY 1988 Solar Buildings Program budget request of $5.25 million for operating expenses, and $0.15 million for capital expenses, will continue progress in establishing the essential technology base required for industrial development of these and other promising new materials, systems, and related technologies. The goal of these research activities is to increase the energy contribution of solar technologies to the point where 70% to 80% of space heating, hot water, cooling, and lighting requirements of many different types of buildings could be supplied at costs that are competitive with conventional fuels.

The FY 1988 program in materials and components includes continued research on new optical and thermal switching films which control solar gain and thermal losses for windows and exterior building surfaces. The switchable film technology has made a large step forward with the recent development of a low-cost process to deposit one of the five layers of a switching film, the counterelectrode layer, on window glass. Work will continue on materials for the optical switching layer itself. Research on innovative collector materials will continue in order to increase thermal efficiencies and reliability, decrease costs, and expand the application of solar technologies to cooling systems and other building energy requirements. For solar cooling, desiccant materials research has led to prototype dehumidifier systems with substantially improved performance using microbead silica gels. However, several organic materials show promise of dramatic increases in moisture absorptivity and will be experimentally evaluated in FY 1988. New phase change materials incorporated in such conventional building materials as wallboards will make it possible to store and use thermal energy provided by solar energy in all parts of the building. Recent laboratory tests have shown that several candidate solid-liquid phase change materials can dramatically increase wallboard heat capacity while meeting self-extinguishing fire tests. Solid-solid phase change materials that should have wider applicability in a variety of building materials will be investigated in FY 1988.

Systems research will continue for both residential and non-residential heating, cooling, and daylighting building applications. Research on open cycle solar absorption and solar desiccant cooling technologies will be aimed at increasing their energy efficiencies, the key to achieving viable solar cooling applications. An important element of the FY 1988 systems research program is the continued development of analytical tools to allow architects, engineers, and homebuilders to predict the performance of systems using advanced materials. In particular, analysis techniques will be developed for integrating these solar technologies with conventional heating and cooling systems. Researchers will also continue to monitor, analyze, and evaluate the performance and reliability of currently employed solar building technology.

PHOTOVOLTAICS

Photovoltaics (PV) continues to make progress toward becoming a significant energy supply option. The partnership between DOE and industry has produced increased conversion efficiencies and reliability and reduced costs, all of which have helped the technology to establish a strong foothold in the competitive energy market, with a broad range of viable applications. In FY 1988 the Photovoltaic Program, with a budget request of $20.1 million for operating expenses and $0.3 million for capital expenses, will seek to advance the basic understanding of technical and scientific issues associated with materials formation and physical phenomena of the PV cell.

Amorphous silicon is an attractive thin-film photovoltaic material which could lead to wide-spread viability for electric power production applications. U.S. research leads worldwide efforts in addressing the issues leading to the optimization of single junction submodules and in the investigation of higher efficiency multijunction concepts. Research and development of amorphous silicon will continue into FY 1988 both as part of an on-going 50:50 partnership with U.S. industrial organizations and with basic work with several universities. The objective of these activities is to achieve 10 percent efficient single junction and 13 percent efficient multiple junction large area submodules.

Polycrystalline thin films also represent promising candidates for meeting the major programmatic criteria relating to cell efficiency, material processing requirements, and performance stability. Progress has been made in the development of low cost deposition methods and increased cell efficiency. FY 1988 efforts will concentrate on defining the scientific and technological barriers to approaching theoretical efficiency which may be as high as 20 percent, and on the development of large area film fabrication concepts for the most promising of these materials.

Partially as a result of DOE's program, single-crystal gallium arsenide and single-crystal silicon solar cells currently hold records for the most efficient photovoltaic conversion of sunlight to electricity. But the efficiency of such materials is inherently limited because not all incident sunlight can be utilized due to the frequency selectivity of the specific materials involved. To overcome this difficulty, researchers will continue to explore concepts such as seeking improvements in selected single-junction cells, exploring ways to mechanically or optically couple cells, and fabricating, as one structure, two or more cells of different materials. The goal of this high priority effort is to achieve 35% efficient small area cells for use by industry as part of its development effort.

The FY 1988 Program will also maintain the unique capability at SERI for precise measurement of material and cell parameters. This work guides researchers throughout the U.S. in understanding and correlating observed physical phenomena. The program will also support other fundamental research in ternary and quarternary compounds and promote basic material work at universities. Finally, the wealth of information, from basic materials theory to complex operations, gathered by the program during its ten years of research and development will be used to assist U.S. industry in their efforts to bring photovoltaic technology to competitive maturity, domestically and internationally. This will be accomplished through report publications, workshops, and technical meetings with the help of the Design Assistance Center.

SOLAR THERMAL TECHNOLOGY

Solar Thermal Technology has begun to attract private commitment to early market opportunities and has the prospect of being competitive with other electric generating systems in the 1990s. Two privately financed 30-megawatt, distributed solar thermal electric plants have recently been placed in service in California. The new units bring the cumulative generating capacity of solar thermal plants to over 110 MWe, enough to meet the electrical needs of more than 55,000 homes and businesses. Three more 30-megawatt plants are scheduled to be placed in service by early 1988 in the same California location. If all existing contracts are completed, it would bring the total capacity to over 550MWe from solar thermal plants. Solar thermal plants, while relying on tax incentives and third party financing, are developing valuable field experience concerning solar thermal reliability in a utility setting - experience that is invaluable as more cost efficient technology emerges from the government/industry R&D partnership.

A new generation of parabolic dish and central receiver technologies is being pursued that have the potential for significantly reducing the cost of solar thermal systems while also increasing performance and reliability. These new concentrators, receivers, and energy conversion devices have the potential to reduce the cost of electricity from the present 13¢/kWh to 5-7¢/kWh for electric power production and to $9/MBtu -- the long-term goals to make solar thermal technology competitive with other energy generating options without tax incentives. During the past year, the Department issued the Solar Thermal "Five-Year Research and Development Plan." This document, whose development was closely coordinated with industry, utilities, and academia, provides a clear research and development path for establishing solar thermal technologies as a viable energy alternative in the 1990s. The FY 1988 program, with a budget request of $14.1 million, emphasizes activities which address the critical technical uncertainties and performance and cost improvements necessary to achieve the stated energy cost goals.

Central receiver heliostats and parabolic dish concentrators of 150 to 200 square meters have been constructed and are under evaluation at the Solar Thermal Test Facility in Albuquerque, New Mexico. These units are three to four times larger than earlier sizes, while unit area costs have been reduced by 40%. A new generation of concentrators, using membranes reflectors in lieu of heavier glass reflectors and support structures, has the potential to further reduce the heliostat and parabolic dish concentrator weight by 75% and further reduce costs by another 50%. A 50 square meters stressed membrane heliostat is currently being evaluated at the Test Facility. Research on 150 square meters stressed membrane heliostats with industry will continue in FY 1988. Cooperative efforts initiated in FY 1987 will also continue with industry to develop stretched membranes for dish concentrators.

Central receivers using molten salt as a heat transfer fluid would allow reductions in receiver size and development of low pressure receivers that weigh less and require less expensive support structures. Research efforts in this area have established the basis for reducing receiver and storage cost by 50%, improving both the overall plant cost and levelized energy costs of solar thermal systems. Operation of a molten salt receiver incorporating commercial design features will begin in FY 1987. The development and testing of molten salt valves, pumps, receivers, and advanced control subsystems will continue through FY 1988. Development of the free-piston Stirling engine, in cooperation with NASA, will continue in FY 1988 for use on parabolic dishes. This engine has the potential to achieve the long- term goals of high reliability and performance at competitive cost. Additional parabolic dish research projects which are underway and will continue in FY 1988 include the development of a thermochemical cell to produce electricity in which the spent chemicals are regenerated by solar energy. Researchers will continue to study approaches for replacing the sensible heat transport methods with thermochemical energy transport and storage processes which have the potential to dramatically reduce thermodynamic losses and thereby increase overall efficiency.

BIOFUELS

Biofuels energy technologies utilize a variety of organic feedstocks, such as wood and other terrestrial crops, aquatic plants, and municipal and other wastes that can be converted by thermochemical and biochemical processes into energy sources.

Biofuels currently are supplying approximately 2.8 quads, or almost 4 percent, of the U.S. energy supply, primarily from the combustion of wood. However, in the longer term, increased usage will come from biofuels - derived gaseous and liquid fuels which have the potential for significant additional contributions. During FY 1988, the Biofuels Program will concentrate on those technologies with the greatest potential for producing liquid and gaseous fuels, focusing on five fuel cycles that integrate biofuels feedstock production and conversion technologies. These fuel cycles produce liquid fuels, such as alcohol, bio-crude oil, and plant oil-derived gasoline/diesel substitutes, and gaseous fuels from terrestrial and aquatic energy crops and wastes. The FY 1988 budget request for Biofuels Energy Systems is $10.65 million.

Terrestrial crops production research includes wood produced by short-rotation intensive culture (SRIC) and herbaceous energy crops (HEC). SRIC reserve has been concentrated on the six most promising species of hardwoods. This effort includes biogenetic techniques to improve both the production and site adaptability of selected species of hardwoods and the evaluation of the stability and inheritability of desired traits. Results from prior years' field trials will be used to update models of coppice dynamics and develop stand establishment recommendations for the selected SRIC species. Oilseed crops breeding research will develop new strains with enhanced energy characteristics. Biotechnology research will be initiated on SRIC and HEC to improve the suitability of feedstocks for specific conversion techniques by altering the genetic characteristics and composition of selected strains.

Aquatics research continues to concentrate on the physiological characterization of specific strains that are being selected for advanced productivity and lipid enhancement/regulation research. Research will be initiated to genetically improve lipid composition. In addition, an outdoor test facility will be operated to gather data on the productivity of laboratory strains.

Thermochemical energy conversion research will focus on liquefaction and pyrolysis of biofuel feedstocks to produce high-value liquid and gaseous fuels. Construction of an experimental medium Btu gasifier will be initiated with prior year funds. Gaseous fuels research will switch to a process for the direct conversion of high-moisture feedstocks to methane and other combustible gases. Thermochemical liquid fuels research will continue on processes that directly convert wood to bio-crude oil and on the processes necessary to upgrade that oil to a feedstock for existing petroleum refineries. In addition, research will be initiated that will examine the relationships of municipal solid waste characteristics (size, purity, etc.) to specific conversion processes.

The biochemical conversion fuel cycles produce liquid and gaseous fuels directly from high moisture feedstocks. Hydrolysis/fermentation technologies produce alcohols directly from energy crops and wastes. In FY 1988 research will concentrate on enzymatic hydrolysis of lignocellulosic feedstocks and on the evaluation and testing of advanced microbial enzyme production systems and acid hydrolysis/fermentation systems. Experimenters will attempt to optimize the process dynamics and conversion efficiencies. Anaerobic digestion, another form of biochemical conversion, produces a methane and carbon dioxide mixture that can be used directly as a boiler or transportation fuel or can be purified to natural gas quality. Anaerobic digestion research will involve the biochemistry of the complex microorganisms and the optimization of reactor conditions, operation, and control.

WIND ENERGY

The year 1986 saw continued expansion of wind turbine capacity with an estimated 300 megawatts capacity added, bringing the installed base to 1400 megawatts. The average size of wind turbines increased in 1986, to slightly over 100 kW. While the rate of capacity growth has slowed and fewer commercial firms exist, a number of stronger manufacturers and developers are continuing research and development and are beginning to explore overseas markets, often with assistance from the Committee on Renewable Energy Commerce and Trade.

The objectives of the Department's Wind Energy Program are to improve the understanding of the fundamental atmospheric physics of wind turbines and to translate this understanding into tools that industry can use to design and develop more reliable, efficient, and cost-competitive wind turbines. The FY 1988 request for Wind Energy is $8.1 million for operating expenses and $0.4 million for capital equipment. These funds will support two basic types of research: (1) the basic science of wind turbine dynamics that includes atmospheric fluid dynamics, aerodynamics, and structural dynamics, and (2) advanced components and supporting research, in which improved airfoils, variable speed operation, wind/diesel controls, acoustic noise generation and propagation, and systems analysis are studied.

In the area of wind turbine dynamics, FY 1988 efforts will be undertaken to increase understanding of turbulence, which is a major issue for performance and design loads, and the effects of terrain on general patterns of wind flow and turbulence that strongly affect energy production and structural stresses in wind farms. A cooperative analysis will be undertaken with industry to ascertain why some turbines have unaccountably experienced extensive structural damage in the windfarm environment. Research evaluations will include wind tunnel and field studies to observe key elements of unsteady flow and performance validation of existing models through cooperative research. Structural dynamics experiments will be performed to correlate the wind input to machine stresses through single and multiple tower arrays close to the turbine. Several fatigue projects will be undertaken in concert with industry and a multitower array will be employed in an experiment involving the combined experience of the national laboratories and industry to provide an extensive data set for subsequent structural analysis.

In the advanced components area, field testing will be performed on two families of improved airfoils, both of which have considerable retrofit potential for existing turbines and are of keen interest to industry. Field testing of variable speed control systems through cooperative research is anticipated. Airfoil development efforts will be continued, guided by results from the basic sciences area. Research will also be undertaken to better understand the design and operation of wind/diesel systems, develop procedures for estimating wind turbine noise, and to overcome barriers such as concern about utility power quality.

OCEAN ENERGY

The Ocean Program conducts research and development on ocean thermal energy conversion (OTEC) technology to a point at which the private sector can make informed assessments of whether applications of the technology are viable energy supply alternatives. This is accomplished principally through research on components and systems modelling. The long-range goal of the OTEC program is to achieve sufficient advancement in technology to result in a projected capital cost of $3200/kWe (1984 dollars). The program strategy focuses on reducing the technical uncertainties which would be associated with 5-15 MWe, near-shore, island based systems. This size appears to be appropriate for the most likely initial OTEC markets. The FY 1988 budget request is $3.0 million for operating expenses.

In FY 1988, the program will emphasize two areas of research: experimental verification and testing and thermodynamic research and analysis. Two previously supported research areas -- material and structures research, and oceanographic, environmental, and geotechnical research -- have provided a data base that is useful for the two FY 1988 research areas, and do not currently require the degree of emphasis that was necessary in past years.

The objective of the experimental verification and testing program is to verify functional feasibility, performance, and operational characteristics of OTEC components, such as heat exchangers and process controls, on a scale that can be extrapolated by industry in designing small plants. During FY 1988, DOE will conduct a set of open cycle OTEC component heat and mass transfer experiments leading to tests at the 165kW level, which is considered to be the point from which extrapolations can be made. In order to conduct seawater tests and experiments at this level, DOE is contributing to the upgrading of a test facility currently being undertaken by the State of Hawaii.

One objective of the thermodynamic research and analysis program is to experimentally determine the effects of trapped gas bubbles and actual seawater on the open-cycle conversion process. Work will be continued on specifying the performance requirements and initial configuration of the low pressure power converter to be employed in the 165 kW open cycle tests. The program will also experimentally validate selected power system analytical models at a scale sufficient to extrapolate the data beyond the laboratory level. Confidence in these models is important if industry is to design open and hybrid cycle power systems that meet the cost goals of the program. Achievement of these goals is dependent upon increasing the output of the power system and reducing the projected life cycle costs of major components.

OTHER SOLAR ACTIVITIES

The FY 1988 budget request for the efforts in support of planned research activities is $8.4 million for operating expenses and $.6 million for capital equipment. These efforts include international, technology transfer, and resource assessment programs, the Solar Energy Research Institute, and program support and direction.

Technology transfer activities provide information to researchers, the general public, and industry concerning renewable energy. These activities include publications, professional seminars, industry workshops, and the Conservation and Renewable Energy Information and Referral Service. The FY

1988 budget request of $2.1 million for operating expenses will continue the technical and public information services at levels commensurate with solar research and development activities.

The international solar energy program provides Federal organizations and industry with a vehicle for cooperative international trade development for renewable energy. DOE is responsible for chairing and providing financial support to a Federal interagency committee, the Committee on Renewable Energy Commerce and Trade (CORECT), which is a forum where industry and the agencies can coordinate the use of existing resources and authorities to exploit export opportunities for the domestic solar energy industry. Additionally, funds are used to conduct a program managed by the Department of Commerce which cost shares, with industry, international exhibitions, special trade missions, and trade development services. The FY 1988 budget request is $0.523 million for operating expenses.

The FY 1988 budget request for the Solar Energy Research Institute (SERI) is $.620 million in capital equipment funds. The funds for SERI will improve the efficiency, safety, and security of this permanent DOE facility.

In FY 1988, funding for solar resource assessment activities will provide information regarding the distribution and spectral (wavelength) and temporal (time of day) variability of solar energy resources throughout the United States. The FY 1988 budget request for these activities is $0.7 million for operating and $.028 million for capital equipment.

Coordination of these activities and other ongoing research and development activities is an important part of the program support and direction functions. FY 1988 requests of $0.937 million for program support and $4.2 million for program direction funds will, among other things, provide technical and crosscutting studies of the various solar technologies, provide for updates to multi-year program plans, continue technical and programmatic dialogue with industry, and manage the diverse research activities in the national solar research program.

GEOTHERMAL ENERGY

The Geothermal Energy Program carries out research and development, in cooperation with industry, on an array of geothermal resource types (including geopressured, hydrothermal, hot dry rock, and magma) and on energy conversion technologies designed to define the technical and economic boundaries of this vast domestic energy supply resource. Program activities include applied research, technology development, and technology transfer efforts that will provide the basis for the timely introduction, by the private sector, of new concepts and products into the marketplace. The funding request for FY 1988 for the Geothermal Program is $15.9 million for operating expenses.

The purpose of the geopressured research program is to define the technical characteristics and recoverability of the large reservoir of hot brine and methane which lies beneath the U.S. Gulf Coast. The FY 1988 program includes experimental well flow testing, tests of the conversion of the combined energy content (thermal and chemical) to electricity, and supporting research on the dynamic response of geopressured reservoirs to production conditions, chemical constituents of the brine, and the possibility of land subsidence.

Hydrothermal research will expand the accessible resource base through an improved understanding of the processes for extraction and reinjection of geothermal fluids, new materials capable of withstanding high temperatures, high pressures, and highly corrosive environments, brine chemistry research leading to techniques to prevent plugging of wells and pipes, and advanced power cycle technologies. In addition, researchers will analyze and synthesize data derived from the very high temperature geothermal reservoirs at the Salton Sea Scientific Drilling Project, and data pertaining to young andesitic volcanoes of the Pacific Northwest.

Hard rock penetration research will improve the technology and reduce the uncertainty of geothermal well drilling, which currently represents about half of the cost of geothermal power and which exceeds the cost of typical petroleum wells by factors of two to four due to the fact that geothermal wells are generally deeper, and encounter harder rock, higher temperatures, and more corrosive fluids than do oil and gas wells.

Experimental program efforts include research on high-pressure water jets combined with rock cutters, mechanics of rock penetration, and drilling fluid loss control. Research also will be carried out to determine the depth and size of a large continental magma chamber, to evaluate alternative methods of energy conversion, and to develop materials and instrumentation capable of operations in the 1000 degree Celsius magma environment.

Hot dry rock research involves the evaluation of the properties of deep crystalline rock and the development of methods to extract geothermal heat from such resources. In FY 1988, the experimental extraction of heat from the large fractured reservoir at Fenton Hill, New Mexico will begin.

GEOTHERMAL RESOURCES DEVELOPMENT FUND

The Geothermal Resources Development Fund was established to broaden the geothermal energy technology base by guaranteeing loans for private sector development of several state-of-the-art facilities. The FY 1988 request is $.072 million in operating expenses which allows for monitoring outstanding loan guaranteed projects.

ELECTRIC ENERGY SYSTEMS

Research in the Electric Energy Systems Program is designed to provide a technology base to enable the future electric energy network to operate more reliably and more economically while protecting health and safety and the Nation's security. The FY 1988 budget for the Electric Energy Systems research is $6.5 million.

Areas of investigation will continue to include determination of the biological health effects due to exposure to high voltage electric and magnetic fields; development of methods and options to ensure appropriate system reliability and the efficient use of resources during expansion of the Nation's future electric networks; development of techniques to provide electric power over a wide range of system conditions including both normal and emergency situations as well as improvements needed for national security; and development of new materials, advanced controls, and new design concepts to improve the efficiency of electric systems. The EES program continues to support research in three program areas: electric fields effects, reliability R&D, and system concepts.

In FY 1988 the electric field effects research will continue to determine the impact of combined electric and magnetic fields on living tissue and whole bodies and initiate abnormal cell growth studies. The reliability R&D activities will focus on completing second level assessment of the impacts of an electromagnetic pulse (EMP) on the current electric power systems operations; and initiating studies on control and operating strategies to mitigate the effects of an EMP. Methods and strategies to operate complex, very large integrated electric power systems through improved system stability, operational and restoration techniques (on-line detection and recognition research) will also continue.

Systems concepts research will continue on interfacial phenomena in dielectric materials and the identification of toxic species in decomposed insulating gases will be completed. Research on control and protection concepts for electric systems with dispersed renewable sources will continue.

ENERGY STORAGE

The Energy Storage program conducts research to provide a technology base to develop advanced storage technologies. The FY 1988 budget for the Energy Storage research is $7.474 million in operating expenses and $.026 in capital equipment.

The program has moved toward a more basic and fundamental research agenda which will continue efforts on advanced energy storage systems to improve the efficiency of energy use and enhance the Nation's renewable energy resources.
The program will permit international cooperation, thereby providing information exchange on the latest technology developments of advanced energy storage systems world-wide. The

energy storage program ranges from fundamental research to exploratory development of technical concepts and includes work on new concepts, materials, and components. The variety of technologies include batteries, fuel cells, thermal storage, and chemical/hydrogen systems. This research provides an alternative for supplying future energy needs by extending the useful life of existing central generating equipment and increasing the economic attractiveness of renewable energy generating sources. As renewable sources of energy become even more competitive and the penetration into the energy networks increases, the need for energy storage for these intermittent sources becomes more important.

These technologies will be used in residential, commercial, industrial, transportation, and utility installations to promote more cost effective energy use.

In FY 1988 the electrochemical storage research activities will continue toward determining the structure, composition, and mode of formation of surface layers on battery electrodes; investigating the mass transfer rates of vertically oriented electrodes to improve electrode performance; and using new analytical tools to study the relationship between the kinetics of electrode processes and the atomic structure of the electrode surface. Other electrochemical research activities will include improving the production process of the beta" alumina electrolyte for the sodium/sulfur battery to yield a more reliable ceramic at a lower final cost; conducting performance tests of sodium/sulfur cells designed for electric vehicle applications; and evaluating and developing new sodium/sulfur, zinc/bromine cell designs for electric vehicle and load leveling applications which have improved durability and reliability. Thermal and chemical storage research will focus on evaluating and improving electrolytic cell materials and design characteristics of these cells for mid- to high- temperature electrolysis for the production of hydrogen; improving the technical and economic viability of diurnal to seasonal thermal energy storage for commercial and industrial application.

CONCLUSION

The future for renewable energy technologies is extremely promising. The advantages of exploiting a huge resource base and the technical, engineering, and applications knowledge gained through research, have confirmed the potential of renewable energy technologies to contribute to the nation's energy supply. Multi-year research programs have been developed to address the critical materials and design concepts issues. Research has made remarkable progress during the past several years toward solutions to technical issues and provides the basis for our optimism concerning the role of these technologies in the future energy supply mix.

The program presented for your review today represents a solid commitment to the continuing development of these technologies.

We are confident that our proposals will increase understanding of the potential for virtually all of the most promising renewable energy options and will substantially contribute to the base of technical information required for informed decision making by industry and consumers.

Thank you for the opportunity to present our budget request.

Senator **Fowler**. Thank you for your brevity and conciseness, and also for the comprehensiveness of your report. With me here is Mr. Ben Cooper on the professional staff of the Energy Committee; we both have some questions for you.

In reading your report, Miss Fitzpatrick, I was pleased that—and in your comments, that you certainly agree that there is a national interest in having an effective R&D program in renewable energy.

If you would please share with us what exactly has been done within the Department, that we can say would lead to a program of cooperation in getting the work to industry that needs to be done in the renewable area?

Miss **Fitzpatrick**. Mr. Chairman, we have been working very hard for the past several years to be sure that our entire renewable energy R&D program is done hand in hand with industry. By that I mean that we begin the planning process with industry. We ask them and other bodies such as the National Academy of Sciences to make suggestions for R&D areas that should be addressed to comment on our multi-year program plans which we have been publishing, and to tell us what it is that they need to satisfy the market demands that they are seeing.

So, we do not even want to start a project unless we have industry's input into it, that it is indeed something useful that will lead to a competitive product.

Senator **Fowler**. Well, how did we fail—we, the government, fail to do that in the case of photovoltaics and wind, and not being able to deliver what the industry—the research, the development and the support that the industry needed?

Miss **Fitzpatrick**. I think that the industries are built on the research and development that was funded by the federal government. The technologies that they are using came for the most part out of federal laboratories, or work done with federal funds in university laboratories, for example.

The vertical axis wind turbine, for example, was developed at Sandia National Laboratory. The aerodynamics improvements that are now being used on new wind turbines manufactured in the United States come out of work done in Federal laboratories. The siting techniques, where is the best place to put a wind turbine and how to analyze the flow of the wind over the terrain came out of work done at Pacific Northwest Laboratories, a DOE lab.

In photovoltaics, the development of amorphous silicon, of metallic overlays for cell interconnection and many other techniques, came out of federal laboratories. A great deal of it has been cofunded with industry but industry has, I think, done a good job of picking up what is coming out of the laboratories and making it into products.

Senator **Fowler**. How do you account for the fact that the Japanese have taken over the photovoltaic business and stolen the march out from the American photovoltaic industry?

Miss **Fitzpatrick**. I think, number one, the photovoltaic market has to be understood in its several segments. The Japanese do have the majority of the world market if you look at total megawatt production of photovoltaic cells.

Most of their market is in consumer products, small cells that are put onto pocket calculators and wristwatches, for example.

That is a very nice market to be in. The markup on the cell itself, when it is sold, is higher than what you can get on a grid-connected power system.

The U.S. industry has gone basically after the power production, true electric generation part of the market. We lead in that. We have over 50 percent of it.

We sell about three times as much as the Japanese sell worldwide in that market and we feel, industry feels, that that is where the real potential lies for growth worldwide especially as the technology develops to the point where photovoltaic generated power will be able to compete with most other sources of electrical generation. About the only thing that we will probably have trouble catching will be hydropower.

So, what is happening is that the U.S. industry is concentrating on a higher technology, a growing, a progressing technology, and eventually a very large world market.

Senator FOWLER. Each year the Administration proposes deeper cuts in all aspects of the renewable energy budget. This year is certainly no different.

Each year the Congress restores most of the cuts because of our belief that we ought not be putting all of our eggs in the fossil fuel basket. We know how to do many of these things and we ought to continue their development.

How can we make the case within the Department and within the Administration as to what can be done and what needs to be done, and when are we going to get the horses pulling together?

Miss FITZPATRICK. This is a very difficult issue for us, and I think our basic position is this: renewable energy technologies deserve the support of federal research. They deserve—or rather, you could justify simply in energy terms more money than we are able to request.

Our budget level is driven by budget restrictions resulting from the need to reduce the deficit, and we do not argue that there is any other source for the level of the request that we put in. Certainly, before we were hit with Gramm-Rudman-Hollings, we did have very substantially higher requests because we felt that they were justified by both the work that needed to be done and the potential contribution that renewable energy will make to the U.S. economy, and the need for that to be able to develop.

So, our budget level is driven by deficit problems.

Senator FOWLER. Anything else?

Miss FITZPATRICK. No, not really, no. Certainly, within the Department we would like to see more.

Senator FOWLER. Are there any proposals in your budget beyond the R&D part that would be designated for implementation of all this research and development, where we specifically go out of our workshops and into the hands of the users of this renewable energy?

Miss FITZPATRICK. Are you speaking of demonstration size projects or——

Senator FOWLER. Everything from demonstration projects to marketing where we actually see the results. Does the taxpaying public—a phrase that the Administration ought to like—actually see and use the results of our labors?

Miss Fitzpatrick. Yes. First of all, within the Federal Government we are working on making federal managers more aware of where renewable energy can be used in things that the Federal Government does. I do not know if you can see it, but directly in front of you beneath the dais is what I suppose is a navigational buoy and it is photovoltaically powered. The Coast Guard is installing these types of buoys virtually throughout their system.

The Federal Aviation Administration is involved in remotely sited weather stations around airports, powered by photovoltaics. We are working on other areas of Federal Government use of power, especially in military installations.

Now, we also have had for about two years an interagency committee called the Committee for Renewable Energy, Commerce and Trade. This is a committee formed of about a dozen of 15 federal agencies, all of which are concerned with using energy, or most especially with financing development projects, particularly overseas.

The committee works very closely with industry. I think you were just given a directory that was just published by the solar industry with our assistance. Now, this is a photovoltaic directory. We worked very closely with them to put them into contact with foreign governments to help them understand where renewable resources exist in the world, what conditions in the economy and the way the governments operate and the needs that are developing in various countries would make certain markets attractive for different technologies, whether they are wind, photovoltaics, biomass, solar thermal, whatever.

We have had a great deal of success working as an interagency committee with such agencies as the World Bank and the Organization of American States to use the funding that is already going to overseas development projects through US AID or the World Bank, for example, to install renewable energy systems which become, then, markets for the U.S. industry.

So, we are seeing those systems being installed today. That is already happening. We are also working through the Department of Commerce in all of their offices in all overseas embassies to open up information to those governments on what is available from the U.S. renewable energy industry, and getting feedback on how our industry should work to penetrate those markets.

So, we are trying to do a lot of very practical things to, as you say, get the systems on the ground and operating and to help our industry to deal in an extremely competitive international market.

Senator Fowler. Mr. Cooper will inquire.

Mr. Cooper. I was interested in your remarks about photovoltaic power market, and I gather from what you said that you think the United States is in a pretty good position to dominate this market in the future because of the research that has been done already. Was that the thrust of your statement?

Miss Fitzpatrick. Yes. The research that is being done now and has been done in the past and we will continue to do is going to lead to better systems, lower cost, greater reliability, longer lifetimes, higher conversion efficiencies. And I think that industry will continue to capitalize on those advances.

Mr. COOPER. So, the things that we read about the loss in the photovoltaic market are likely to be turned around with respect to sales in power systems overseas?

Miss FITZPATRICK. No, I think you always have to remember, if you are talking just about the power systems, we have a lead and we should be able to maintain that lead. But if you look at gross PV sales for all uses including consumer products, there is that huge market that the Japanese have.

And, since the U.S. consumer products industry lost a lot of the pocket calculator, wristwatch, et cetera type of market years ago, there was really nothing for our industry to piggyback on, which was the most unfortunate thing.

Mr. COOPER. Do you feel that present funding levels, present DOE policies, present trade policies are going to enable us to maintain the lead that we have in the power market? My point was, your testimony is that the current policies are going to result in the United States maintaining its lead in power sales overseas that we have now?

Is that correct?

Miss FITZPATRICK. I think the current policies and our R&D program will enable the industry to maintain its lead. Of course, you also have to assume that the industry will in fact progressively pursue the new markets and transfer the technologies.

Mr. COOPER. They probably agree with that assessment.

Miss FITZPATRICK. Yes.

Senator FOWLER. What would you describe as the most promising renewable energy technologies, and on what do you base your choices?

Miss FITZPATRICK. You are asking me which one of my children I love the most.

Senator FOWLER. No, I'd ask that in a different way.

Miss FITZPATRICK. I think you have to answer that in the context of each particular kind of energy you want. Do you want electricity or a liquid fuel or a gas fuel?

Senator FOWLER. To follow up on Mr. Cooper's questions, I'm curious about the possibilities for renewable energy and its usage by the private sector and by the citizenry of our country, and also the ones where we believe that we unquestionably have an edge that will enable us to be dominant in any kind of trading or internationally competitive market.

Miss FITZPATRICK. I think that for electrical generation, photovoltaics and solar thermal undoubtedly have a huge potential, some of which is already beginning to be realized. To some extent, though, those are limited or will first reach their best markets in areas that have high solar—high insulation, the sun shines a lot and it shines rather high above the horizon. Those are the best markets to begin with.

Those markets also are peaking power markets, which is the most expensive kind of electricity, the kind that you need on hot summer afternoons when everybody is running an air conditioner. Again, that means that it's easier to compete in that market because a utility already has to pay a fair amount of money for its power, for its peaking power, and that means you don't have such a stringent cost goal to meet.

For base load generation around the clock, biomass eventually has very large potential. Biomass also has the potential of providing liquid and gaseous fuels and those fuels are going to be especially important to us as we try to move our transportation system from a petroleum base to a nonpetroleum base.

We are going to have to find ways to make abundant and fairly inexpensive liquid and gaseous fuels. So that potentially, in the longer term, I think is an extremely important segment of our energy economy that biomass can help to meet.

Those, I think, are probably three of the largest. Wind will continue to make a significant contribution. Geothermal is a huge resource potentially. You are talking about tapping the heat of the earth itself, which is to some extent at least renewable.

The geothermal production in this country is now somewhere over 2,000 megawatts, mostly in California, and we have tapped into the easy things, the steam to convert some of the brines, the hot fluids. It is a more difficult job but we are already learning how to do that and in fact have some plants on line.

That is a resource that will continue to be developed as we learn how to use what are called the lower quality reservoirs, the lower temperature reservoirs, and that can be used for electrical generation and also for direct heat for manufacturing or food processing applications, and it is already widely used to heat buildings. So, geothermal will continue to be a growing resource.

Geopressured is also a huge resource. The methane——

Senator **Fowler**. How many children do you have?

Miss **Fitzpatrick**. Oh, I have lots of children. I'm like the old lady in the shoe. But I think for the near term applications we are already seeing as commercially viable technologies our photovoltaics and solar thermal and geothermal.

Let me add also that we integrate into all of our research the electric distribution systems and electrical storage, and different means of storage, electro, chemical and mechanical and thermal storage. These are extremely important technologies to develop in order to make the renewable system fully integrated so that you don't have just—you don't have power from it just during the peak sunshine hours but around the clock, and in order to transport the power that is generated at the system to where it is needed, and we can't afford to ignore those parts of the total system.

Senator **Fowler**. Madam Secretary, thank you.

Mr. Berg, do you have any comments, or Mr. Martin?

Mr. **Berg**. I just wanted to point out one thing, Senator. Both your hydropower and your geothermal will provide your base load capability which is very important.

Senator **Fowler**. I don't know if you have heard the story of the Queen's royal yachtsmen sailing in the night with Diana and Charles. He sees this incredible light approaching. He says, "Her Majesty's yacht approaching," he flashes, "Give way." No answer. Getting closer and closer. He says, "Princess Diana, Prince Charles aboard," he flashes, "Give way." There is no answer. He flashes, gets out all his lights and flashes, "I am Francis Kimper, Her Majesty's chief yachtsman, give way."

For the first time, the lights come back. "I am Fred Smith. I've been running this lighthouse for 27 years." [Laughter.]

I welcome the Senator from New Mexico. The Administration has just completed their testimony, but, if you have any questions or comments you care to address, we are delighted to have you.

Senator DOMENICI. I am delighted. Thank you very much.

I find myself in a position where I cannot be two places at once. As you suspect, that is required of us sometimes.

I was down at the Budget Committee, but I did not want to let this meeting pass without showing my genuine interest in your efforts here, and I ask that my statement with reference to this be made a part of the record.

Senator FOWLER. It shall be.

[The prepared statement of Senator Domenici follows:]

OPENING STATEMENT
SENATOR PETE DOMENICI
RENEWABLE ENERGY TECHNOLOGIES
MARCH 24 HEARING

GOOD AFTERNOON. ALMOST EXACTLY ONE YEAR AGO, THIS SUBCOMMITTEE HELD A SIMILAR HEARING, ON THE DEPARTMENT'S PROPOSED BUDGET FOR FY'87 IN THE AREAS OF RENEWABLE ENERGY AND CONSERVATION. I REMEMBER THAT, AT THAT TIME, THE COMMITTEE WAS HIGHLY CRITICAL OF THE DEPARTMENT'S DEVASTATING CUTS IN RENEWABLES AND CONSERVATION PROGRAMS. I REMEMBER THAT WE STRESSED THE IMPORTANCE OF COST-EFFECTIVE R&D IN THESE AREAS, DESPITE GRAMM-RUDMAN, AND DESPITE THE OIL GLUT, SO THAT WE'D HAVE THE ADEQUATE DOMESTIC ENERGY TECHNOLOGIES AVAILABLE WHEN WE NEEDED THEM.

WELL, HERE WE ARE AGAIN, IN ESSENTIALLY THE SAME SITUATION. THE DEPARTMENT AGAIN PROPOSES TO CUT ITS RENEWABLE AND CONSERVATION BUDGETS IN HALF. WE HAVE AN EVEN WORSE SITUATION WITH RESPECT TO THE OIL GLUT. AND DEFICIT REDUCTION TARGETS ARE MORE CHALLENGING THAN EVER. SO WE ARE REALLY IN A BIND.

I RECALL BACK IN 1981, WHEN WE HELD HEARINGS ON THE STATUS OF OUR PHOTOVOLTAIC INDUSTRY, HOW DIFFERENT THE PROBLEMS WERE. AT THAT TIME, WE WERE IN A TRANSITION PHASE IN TERMS OF THE FEDERAL ROLE IN RENEWABLE R&D. WE WERE TURNING AWAY FROM ARTIFICIAL, GOVERNMENT-INDUCED MARKETS, AND TURNING TOWARDS A MORE FUNDAMENTAL RESEARCH AND DEVELOPMENT PROGRAM IN PURSUIT OF MEANINGFUL TECHNOLOGICAL ADVANCEMENTS. WE ALSO RECOGNIZED THE TREMENDOUS POTENTIAL OF THE EXPORT MARKET, ESPECIALLY TO LESSER DEVELOPED COUNTRIES. WE EVEN PROVIDED SPECIFIC APPROPRIATIONS TO THE COMMERCE DEPARTMENT TO PROMOTE EXPORTS OF RENEWABLE

TECHNOLOGIES. WHILE THE SAME PRINCIPLES THAT WE RECOGNIZED BACK IN 1981 ARE STILL VALID TODAY, WE SEEM TO LACK THE WILL TO CARRY THEM THROUGH. NO WONDER, CONSIDERING THE WRENCHING EFFECTS OF TIGHTENING BUDGETS AND LOOSENING OIL SUPPLIES. RENEWABLE ENERGY IS NOT THE ONLY ONE TO SUFFER, EITHER. WE SEE THE SAME EFFECTS HAVING CAUSED THE DEMISE OF THE SYNTHETIC FUELS CORPORATION, AND WE SEE SHARP REDUCTIONS IN FOSSIL AND NUCLEAR R&D BUDGETS. WE HAVE SIMPLY LOST OUR WILL.

I, FOR ONE, DO NOT INTEND TO LOSE SITE OF THE VALUE OF ALTERNATIVE ENERGY TECHNOLOGIES. THAT'S WHY I INTRODUCED LEGISLATION EARLIER THIS YEAR IMPOSING AN OIL IMPORT FEE -- IN ORDER TO BOOST THE ECONOMIC INCENTIVES FOR DEVELOPMENT ON ALL ENERGY FRONTS.

THAT'S ALSO WHY I STILL SUPPORT AN ADEQUATE RESEARCH BASE, AND WHATEVER OTHER FEDERAL EFFORTS THAT MIGHT BE NEEDED TO PROMOTE OUR RENEWABLE INDUSTRY'S HEALTH. I DO NOT, HOWEVER, BELIEVE WE SHOULD CREATE ARTIFICIAL DEMANDS FOR RENEWABLES -- FOR WE TRIED THAT ONCE BEFORE, AND IT FAILED. WE SHOULD INSTEAD LOOK TO THOSE FEDERAL POLICIES AND PROGRAMS THAT WILL CREATE A TRULY "CUTTING-EDGE" RENEWABLE ENERGY TECHNOLOGY BASE THAT WILL SURVIVE AND PROSPER IN THE WORLD MARKETS.

I LOOK FORWARD TO THE IDEAS AND RECOMMENDATIONS THAT TODAY'S WITNESSES MAY HAVE TO PROMOTE THOSE POLICIES AND PROGRAMS.

Senator DOMENICI. I will try a couple of questions. We are going to have a vote here in a minute, but if I do not finish them we will submit them for you and you can answer them in due course.

If Congress were to take some action to help foster renewable energy programs, what action do you think would have the most beneficial effect on our industry, provide more money for research and development, provide market and manufacturing incentives such as tax credits, accelerated depreciation, manpower training, et cetera, or none of the above, and if you have your own that would do more, give me your version.

Miss FITZPATRICK. Senator, I think that all of those things would be helpful to some extent. I think that we need to continue to work closely with industry to identify the research issues that really need to be addressed, and the things that can be done most helpful to them. And we are trying to do that and we will be happy to share those thoughts with the Committee.

We are also aware that there are certain policies, tax policies that tend sometimes to discourage capital investment or capital formation, and renewable energy systems being capital intensive, suffer, along with some other types of systems, from the bias or disincentive for capital investment.

If you have to put up a system and most of the cost of that system is fuel which you can immediately expense as you buy it, and a renewable system will be capital intensive and have little or no fuel cost over its lifetime and yet you have to put up your money but you can't depreciate it except over 20 or 30 years, then you might view that as being not in your best interests and go with the fuel expensing system.

So, that is something that we are exploring. I don't know what can be done about that, exactly. I'm not supposed to suggest that we should have another tax reform bill, but I think it is something to keep in mind as bearing on all new investment and in particular on renewable systems.

Senator DOMENICI. Mr. Chairman, I have three additional questions. I would ask that the witnesses answer them within the timeframe you sét for keeping the record open, and I have no further questions.

Senator FOWLER. Thank you, Senator Domenici.

Madam Secretary, thank you, and your staff, for being with us. We appreciate it.

Senator DOMENICI. May I ask one last question?

Senator FOWLER. Please.

Senator DOMENICI. I assume you would agree, would you not, that probably the thing that would do the most for enhancing America's use of renewables and pumping money into basic research on the private sector end is related to the price of crude oil. If it were not so cheap, there would be more chance of those coming on board, or conversely if it were higher in terms of the basic energy against which we measure everything that probably renewables would have a better chance.

Is that a fair assessment?

Miss FITZPATRICK. It is true that when generally the prices of energy are low, any new technology which is having trouble competing, getting its own price down, is at a disadvantage. If your object is simply to get more renewables on line, then lower oil prices are a disadvantage.

If your object is to supply the energy that the economy needs at a reasonable and manageable cost, then you might have another view of it.

Senator **Fowler**. If the gentleman will yield—I don't mean to turn his question—but his question is energy security and energy self-sufficiency in this country, then how do you factor in the price of oil in the achievement of that goal?

Miss **Fitzpatrick**. To the extent that renewable energy eventually will provide a larger share in contributing to our energy security, that process will be speeded up by higher general energy prices and it will be relatively slowed down by lower prices. I agree with his basic premise, yes.

Senator **Domenici**. Mr. Chairman, I just wanted to make that point in closing. I know we are going to have to go and vote, but I don't think there is any question that an economic system such as ours, free enterprise capitalistic system, of which this Senator is a staunch advocate, that there is no question that we are going to have less renewables available rather than more, almost regardless of what we do in research programs, almost, so long as the market indicates that we have oil and gas as cheap as they are now or as cheap as they were a few months ago for any prolonged period of time.

We have just literally seen it happen, no matter how you try to sell this beautiful solar energy to residential users, until the average person buying an average house can see it clean, neat and nice when that realtor shows him what it is going to cost to buy the house and what it is going to cost to keep the house going by way of utilities, we are just not going to get that used.

It was moving up. You could see it in subdivisions in my state. They had beautiful advertising brochures to show them how it would work. That is disappearing rapidly because the price of natural gas in a state like mine is cut in half.

What they are talking about, the average homeowner is talking about, the down payment, the mortgage payment including ad valorem taxes, and what is your estimate of utilities per month, and it is just tough to find some way to substitute those kind of new technologies and renewables even if you can show them all kinds of 20, 25-year advantages, you will find them but you will not find them in the average house which is getting sold in huge numbers to average working people who are putting up 30 percent, 35 percent of their earnings to pay for that house.

That is happening in all different kinds—and that was the purpose of the question.

Senator **Fowler**. Well, after that very fine discourse on the law of averages, two better than average Senators must go vote. We shall return to a panel of witnesses, and Mr. Robert Nathan.

[Whereupon, a brief recess was taken.]

Senator **Fowler**. Is everybody ready to go? I think that is the last vote, at least for a couple of hours, so we ought to be able to hear from Mr. Nathan and then from our panel without any interruption.

I am pleased to welcome as the next witness Mr. Robert Nathan, a prominent economist, of Robert Nathan & Associates, Washington. We have read your fine statement, Mr. Nathan, and I will make it a part of the record in its entirety.

I would appreciate your summarizing your statement. Any additions or deletions we will welcome, including discussion of the Administration's statements, and points and areas of disagreement.

STATEMENT OF ROBERT R. NATHAN, ROBERT NATHAN & ASSOCIATES

Mr. NATHAN. Thank you very much, Mr. Senator. I don't think I will mention any deletions but I will make my summary very brief.

It seems that in normal times the marketplace could help us solve our energy problems but I do think that in the face of the horrible financial and economic problems we face in our balance of trade and balance of payments and moving from the biggest creditor nation in the world to the biggest debtor nation in such a short period of time, and our tremendous expenditures for the national security, that these are not normal times and I do not believe, Mr. Senator, that we can rely on the marketplace entirely to solve all these problems.

First, the real crisis, I think derives—that we have in energy—derives from the fact that the renewables are likely the only meaningful solution we are going to have over time to our energy problem, because fundamentally the oil production is pretty much at peak and has passed its peak in many ways because of the drop in prices having resulted in lots of varieties of wells closed and a very, very sharp drop in drillings.

And, so that the oil picture is not a favorable one. Gas is favorable in terms of the reserve prospects but the price of oil does have an impact on the attractiveness of gas and that deep drilling is not going to take place because it is far too costly relative to the present prices of oil.

Coal ought to be a major factor but unless we do an awful lot more research and development in terms of environmental problems we are not going to achieve it, and as my paper states I think we ought to take a hard look at the transportation costs by the railroads since the Staggers Act, but that is a different issue, but I do not think coal is going to give us the solution we would hope for.

Finally, while nuclear energy could be a tremendously important factor and is in many, many countries, it is not in the United States and there are real safety problems and concerns. Well, the then question is, what do we do about the renewables? And let me say that just a month ago the GAO came out with a statement analyzing the R&D criteria and whether the Department of Energy was adhering to its criteria.

I would like to say very briefly, Senator, that in my judgment the criteria being followed by the Department of Energy are not satisfactory. They are giving primary importance to long-term, high-risk, high-payoff energy research and not anything beyond the early stages of development.

When one realizes that our big problem is in the manufacturing area, in the production area, in quality, in price, efficiency, that to concentrate the R&D and the research component of an R&D, I think is a serious mistake and until the market develops, for instance for many of these renewable energies, the marketplace cannot do it because you have to have help in terms of getting demand.

I think that the tax credit situation that did prevail for quite a time on home use for hot water and air heating and space heating and the like was helped tremendously. If we had kept those tax credits on for a bit longer we would have helped develop the market and that, of course, would have been a tremendous stimulus.

But I do think that the photovoltaic and the thermal power, I agree with the Secretary that those are two very, very important areas and I think the most important thing is that they are making very considerable progress but that does not mean that they are at that stage where they will take off on their own and more research and development is necessary, and I think it is necessary and I think we ought to support it and I will mention very briefly where.

Let me say in all of the renewables, whether it is wood or wind or biomass, geothermal, a whole range of areas, I think all of them ought to be helped except up to a point where obviously from a financial and a technical point of view it appears to be so remote as to be almost improbable at all.

But on the other hand, I do believe that cost and market are very important factors and as far as cost is concerned, I did testify, Senator Fowler, in support of a fee, import fee on oil because I felt that unless we did set some kind of a rate, maybe around $18 or $20 a barrel and had a variable fee, that we probably would cut our domestic exploration or of a lot of other areas way down.

But no matter what the price of oil is, I think we have got to take a hard look at, what is it going to take to develop these renewable energies, and just as we have run our defense budget up to around $300 billion from a figure barely over half of that six years ago, I do think we have got to recognize that it is going to take some expenditures.

A lot of people say you can't throw money at problems and solve them and I think that is true, but a lot of problems can't be solved if you don't have any money or resources. And, I do believe in this area we do need, not cuts in budget but at least a maintenance in R&D budget, but they have been cut very, very substantially.

I do believe we need tax credits and I hope that they might be restored. I do believe that we need investment incentives, whether it is accelerated depreciation or concessionary lending at certain rates, whatever it is, and I do believe that the DOE budget has been reduced substantially.

The final question I would pose with respect to these budgets, and government resources to do the job, is that in a very meaningful sense we can sort of hide behind Gramm-Rudman and say, we just have to cut everything. If we do, we are not going to have an educated people to compete with the developing countries at all and we are not going to have security, we are not going to have anything.

I think what we have got to do is look at the priorities. And in my judgment, Mr. Chairman, unless we give high priority to the renewables, 20 years from now or 30 years from now they may come along anyhow.

The question is our national security. I happened to be Chairman of the Planning Committee of the World Production Board in World War II, and I assure you that that time, if we had had an energy shortage we would never have undertaken successfully the mobilization we did. But it was the fact that we had plenty of energy and we were able to do a tremendous job without which I think we wouldn't have done it.

So, I would say that what we ought to do is take a hard look at our budget and give high priority to renewables, and I know this is an unpopular subject but I think the American people would rather pay a little more taxes and have energy security than to maintain the cuts that have been made and take tremendous risks in our society.

Thank you.

[The prepared statement of Mr. Nathan follows:]

TESTIMONY OF
ROBERT R. NATHAN

Before The
SUBCOMMITTEE ON ENERGY, RESEARCH AND DEVELOPMENT
U.S. SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
MARCH 24, 1987

Mr. Chairman, and Members of the Subcommittee on Energy Research and Development, thank you for this opportunity to discuss renewable energy in the context of an overall energy perspective and our national economic and security challenges. This Hearing is especially significant because of the high degree of complacency about energy in the United States.

All but forgotten are memories of the oil embargo of 1973 and the unprecedented explosion in oil prices in 1974. Long gas lines and fear of recurring shortages and worsening inflation have faded like bad dreams. Nor do Americans recall astronomic rises in oil prices again in 1979 and 1980.

World oil reserves seem adequate to meet all foreseeable demands well into the twenty-first century. Also, the prospects for natural gas supplies in the world are favorable for several decades. But embargoes on oil exports from countries with huge reserves could recur. Also, it would be foolhardy to conclude that OPEC should be written off. Oil prices dropped precipitously in 1986 as the OPEC Cartel was weakened by cheating and bickering. But the cartel recently achieved sufficient commitments of production constraints from exporting nations to push the price back up to $18.00 a barrel from the 1986 trough of about $10 per barrel.

Adequate supplies of oil in the world does not mean that the United States will have no oil and energy problems. It is generally agreed that the the present level of oil production in the United States of about 10 million barrels per day cannot be measurably increased. In fact, it cannot be sustained for long. Dependence by the United States on oil imports is certain to increase.

The Energy Security Report of the Secretary of Energy this past week emphasizes the seriousness of the oil shortage in the United States and our increasing reliance on oil imports. Hopefully, the conclusions of the Secretary will be taken seriously by all branches of the government and by the public. Former Secretary of Energy Hodel, who is the present Secretary of the Interior, has had the vision and the courage to speak openly and publicly on this problem for some time.

The timeliness and the significance of this Committee's Hearings can best be appreciated in the context of our nation's economic and security problems. The persistence of recent unprecedented budget deficits, even during years of recovery, has had severe adverse consequences on our international economic status. Our deficit in trade and service accounts was in excess of 140 billion dollars for calendar year 1986. The merchandise deficit was even higher, approximately six times its level as recent as 1981.

The huge budget deficits have exerted upward pressure on interest rates. Interest rates have fallen substantially from their peak levels, but in real terms they are still at historic highs. Inflation has dropped proportionately more than the drop in interest rates. High real interest rates have attracted capital inflows which helped finance our federal deficit and provided funds for private investment. The capital inflow contributed to the marked rise in the dollar relative to other currencies. The over-valued dollar dampened foreign demand for more costly United States exports and increased United States' demand for less costly foreign products. The drop over the past two years in the value of the dollar has yet to make a significant dent in the trade deficit.

The United States was the largest creditor nation in the world only a half dozen years ago. It is now the largest debtor nation in the world. It has been estimated that the present net debtor position of nearly 200 billion dollars will grow to a trillion dollars by the early 1990s. The certain increase in oil imports will aggravate our trade deficit or, at least, slow the decline in that deficit. This prospect is particularly distressing when our trade and financial deficits are so large. Also, the possibility of higher oil prices is a matter of important concern to the United States because of the growing fear of renewed inflation.

If the market in oil were free, without any cartel, there would be little danger of a sizeable rise in oil prices for, perhaps, the next decade or two. However, the recent agreement within the OPEC and with other oil exporting nations was based on the recognition by these nations that if they complied with production quotas, prices would be higher and all oil exporting nations would benefit. The dangers of inflation will be enhanced if the OPEC cartel continues strong and effective.

A strong productive economy is an essential ingredient of national security. If our experience in mobilizing for an all-out military effort during World War II is an indicator of future mobilization requirements, the critical role of a strong economy is obvious. In that mobilization effort, one sector that was of limited concern was energy. There were ample domestic oil supplies for the spectacular expansion of production of materiel and essential civilian needs.

I had the privilege of serving as Chairman of the Planning Committee of the War Production Board and was deeply involved in the economic mobilization effort. We had to concern ourselves with importing rubber and copper and other scarce materials, but energy was not one of our bottlenecks.

Sea channels were highly insecure. Until our navy was greatly expanded and production of merchant vessels was tremendously increased, we suffered huge losses of both vessels and essential supplies from abroad. That experience should make us nervous about depending on such a critical item as oil imports. Losses of vessels barely offshore should make us realize that reliance on oil from Venezuela, let alone Western Africa or the Middle East, could strike a serious blow to our national security.

The oil issue should not be viewed as an "all or nothing" alternative. In other words, total energy independence is something that is highly unlikely for the United States for many, many years to come. But, it is of utmost importance to reduce dependence on external sources. I served for about 10 years as Chairman of the Executive Committee of Americans For Energy Independence, which focuses on the urgency of increasing domestic supplies of energy and strongly supports conservation programs.

Conservation is certainly an important part of a program to reduce our dependence on oil imports. A combination of high prices plus a national sense of urgency in the 1970s led to considerably greater efficiency in the utilization of oil and other sources and forms of energy. Industry was particularly successful in adjusting and adapting its productive processes to energy conservation. In the automobile industry there was a noted shift from large gas guzzlers to automobiles and trucks requiring less oil and gasoline per mile driven. Individuals tended to reduce their use of cars. Home use of energy was curtailed. But all of these efforts to conserve energy have diminished or have disappeared. There is a great need for national leadership to alert the people of the United States that we are increasing our oil imports, which will have adverse economic and security implications for the future.

Obviously we must do more than just identify the problems and the dangers that face us and assume that solutions will be forthcoming. What is needed above all is leadership in the executive and the legislative branches of government, as well as industry, labor and consumer organizations. Unfortunately, some leaders have belittled the problem and have insisted that the marketplace will take care of everything.

The very fact of these Hearings on research and development of renewable sources of energy is a highly significant step toward alerting the nation to the difficulties ahead in the energy field. Another helpful undertaking was the report of the General Accounting Office to the Chairman of the Subcommittee on Fossil and Synthetic Fuels, Committee of Energy and Commerce, House of Representatives, issued last month. It dealt with research and development in the field of energy.

It is essential that we make renewable sources a major target, because of serious constraints on other sources of energy. Coal could conceivably make a big contribution toward greater energy independence. But coal expansion is not going to occur quickly, especially if challenging environmental and transport problems are not solved. More research resources must be devoted to overcome environmental disadvantages associated with coal. Acid rain was not taken seriously until Canada complained loudly and repeatedly that acid rain was destroying its lakes and fish and other resources.

It is unrealistic to expect that industry alone, whether it be the coal mining industry or converters of coal to electricity, will provide all the resources needed to solve these environmental problems. Government support will be needed in the form of research grants, tax incentives, or financial concessions, along with stricter regulations. Both "the carrot and the stick" will be required. This and related problems are not getting the attention received a few years ago.

Another constraint on coal concerns the marked increase in rates charged by the railroads for transporting coal. Under the strong deregulation thrust in recent years, the Interstate Commerce Commission has not been helpful in limiting rate increases for coal movements on monopolized routes by railroads. Those in the Congress concerned with energy ought to take a hard look at Interstate Commerce Commission abuses in the name of the Staggers Act.

Another important area concerns nuclear energy. The issue there is mostly one of safety. It has now been approximately a decade since the Three Mile Island accident. Then along came the Chernobyl accident in the Soviet Union, which intensified fears about the safety of nuclear energy. There continues to be a lack of agreement on dealing with nuclear waste. Views of scientists on the risks of nuclear energy vary greatly, just as the concerns of the public range from extreme support to uncompromising commitments to bringing an end to nuclear energy, even calling for destruction of all existing facilities.

Nuclear energy could make important contributions toward the goal of greater energy independence. But that depends on whether adequate research and development outlays are made to overcome safety problems with credible solutions. Countries around the world are continuing to move far ahead of the United States in the use of nuclear energy. Orders for nuclear facilities in the United States have been nil for quite some years. The companies that produce nuclear facilities are in no position to spend larger sums for research and development.

Some observers believe the sharp decline in new oil and gas drilling activities may be a blessing in disguise. They contend it would be well to keep more oil reserves in the ground in case foreign supplies are cut off during an embargo or war. They would cut domestic output of oil currently and rely on more imports. If drilling is reduced further there will be no discovery of new oil reserves. Drilling and capping producer wells is a losing game. Without new drilling the actual production of domestic oil would drop much more rapidly than now projected. Encouragement of drilling would seem to be in the national interest but there will be strong opposition to proposed increases in the percentage of cost depletion allowance. It is interesting to note that when our oil supplies were ample, we allowed a 27½ percent cost depletion. As our domestic supplies became increasingly scarce and imports rose, we eliminated the percent depletion for large oil companies and lowered the rate for independent producers. But increasing percentage depletion allowances is not a likely prospect.

I believe it is desirable to keep domestic oil and gas production high. One of the ways to do this is to set a fee on imported oil at some given price such as 18 or 20 dollars a barrel, and have the fee vary as international prices of oil rise or fall. At a price less than 18 or 20 dollars per barrel there will be only limited exploration for natural gas, especially large deep reserves.

No matter what is done with respect to increased coal usage or nuclear energy or domestic oil and gas production, there will continue to be a huge gap between total domestic supplies and total energy needs far into the future. Renewable possibilities must be given serious attention. An important question relates to the government's support for research and development. In analyzing research and development activities supported by the government, the Controller General sought to determine whether preference was being given to long-term, high-risk and high-payoff technologies in their early stages of development. These criteria dominate the Department of Energy's research and development policy. I question whether these are the appropriate criteria. It is at least as important or more important to provide incentives and support for the development component of research and development and not just basic research. Also, incentives are needed at later stages of production. The marketplace alone will not do the job that needs to be done.

At a recent meeting I attended there was an intensive discussion about the future of the American economy. The head of one of America's foremost research and development organizations, if not the best, drew an interesting distinction between research and manufacturing. It was his observation that the United States was still ahead of Japan and other countries in technology. We are developing new technologies at a pace that should keep the United States reasonably in front. However, we were falling behind in manufacturing and production, including quality and prices. Our machinery and equipment, our training of manpower, our management and our high overhead are where performance is deficient. We need to attack our production problems if we are to reestablish our competitive posture.

There is a distinction between technology and the manufacturing or production process. The speed of technological changes makes the transmission of know-how very rapid. There aren't many secrets anymore. The competitive advantage lies in exploiting markets, in quality control, in improving productivity and efficiency, and in achieving lower costs. If one accepts this view then any positive roles of government should be directed at least as much to the development component of research and development as to the research component. It is at the later stages of development where large investments are needed and where productivity must be improved. That is where concessionary financing and tax incentives are required.

Many economic analysts have tried to identify what influences and determines international competitive advantages. They often conclude that many nations focus strongly on providing incentives to manufacturing in the form of concessionary interest rates, or accelerated depreciation, or tax credits, or manpower training or other supports. These special efforts in other nations are designed to help industries to improve quality and cut costs and be more competitive. Incentives are not provided in the same measure in the United States. Also, our government has tended in recent years to become even more neutral than in the past. The gap between what other countries are doing for their producers and what is being done in the United States is a growing one, thereby increasing the relative advantages of industries abroad relative to industries in the United States.

Reliance on the marketplace in major degree is proper and generally desirable in a free-enterprise society. However, there are limitations to what the marketplace can accomplish, especially in sectors like energy where problems are most complex. The "flat playing field" concept sounds good in principle but it can fail in practice. It is especially serious in a world in which some national governments give substantial support to local industries and other countries like the United States do little for their producers. Especially in dealing with energy, we face problems that competition and free markets will not always solve. If we are to follow the "flat playing field" principle in the United States, we should seek to make the playing field flat around the world.

The Congress and the Administration should look hard at what is happening in international markets and especially in the energy field. The years ahead are going to bring increasing challenges to our competitiveness. Many of our problems are not going to be solved in the marketplace because other countries give greater support to their industries than we are prepared to give.

The solar energy industry is certainly a good example of an energy source that has made considerable progress but still is a high risk sector and needs support. It is still difficult to project the prospects in the solar energy industry segments of photovoltaics, solar thermal, and space and water heating or other methods of exploiting the limitless supply of energy from the sun. The water and space heating component of solar energy did make significant progress but not enough to be fully viable without special tax credits. The termination of tax credits for residential solar systems has had a severe adverse impact on that sector. There are those, of course, who believe that if, after a decade of tax credits, the marketplace has not demonstrated that it can grow and prosper without incentives, then it should be allowed to disappear. I testified before the House Finance Committee on this subject in the past in support of continued but shrinking tax credits. I believe it was wrong to drop the tax credit for residential applications too soon.

As far as the photovoltaic segment is concerned, major progress has occurred. The prospects continue to be most encouraging. Costs have dropped dramatically and there is growing confidence that it will be a competitively priced source of energy in just a few years. But it still needs government support for research and development. Of serious concern is the evidence that the Japanese photovoltaic industry is rapidly expanding its productive capacity and its penetration of world markets. They may well severely constrain if not eliminate the industry here in the United States. That would be most unfortunate. It is difficult to document what many industry leaders in the United States are convinced is taking place, namely much more generous support from the Government of Japan relative to assistance to the United States industry from our government.

Another solar industry segment with prospects of important developments is solar thermal power. There has been not only encouraging technical progress but marked declines in costs of facilities, improved maintenance economies and greater production efficiencies. I am an economist and not a scientist or industrial engineer. However, I cannot help but be impressed and encouraged by statements and testimony of operating leaders of companies in the solar industry on the discoveries and the investments and the progress made in this potentially significant sector of the energy industry.

Certainly, as far as wind is concerned, some experiments are continuing and prospects are hopeful, but here, too, substantial further development will be remote without special incentives. Research is costly and investments in production facilities are substantial. They cannot be borne by industry alone, especially when prices for competitive sources of energy drop sharply. With lower oil prices it is to be expected that private efforts will be curtailed.

The nation's long-term well-being often depends on the government's help in bearing some of the costs and risks. In the national interest, we should support energy research and development with patience and persistence. Solar and wind are certainly not the only renewable energy sources of importance. We need to support all sources that reveal any meaningful signs and prospects for significant progress, including biomass, hydroelectric, synfuels, geothermal, coal gasification, and other sources which can supplement traditional energy output.

Some individuals conclude that since the gap has increased between current costs of energy from new sources and present market prices for energy from traditional sources, the government should cease its support. They contend that when the gap shrinks, that is the time to stimulate the development of renewable sources. This is shortsighted. As long as there is a reasonable basis for anticipating progress in research and development activities in this field that would shorten the day when new sources could become viable, support should be forthcoming. We need to remember again and again that oil imports are rising and that our dependence on foreign sources will increase. That will hurt our economy and our security.

A frequent reason given for discontinuing incentives is the Gramm-Rudman Act and budget deficits. Throwing money at problems does not often bring solutions but it is even more correct to say that without resources few difficult problems can be solved. It is true that our huge budget deficits are like a malignant ailment in our economy. They must be reduced. But in that effort serious attention must be given to the cost-benefit consequences of putting money into energy research and development as compared with expenditures for other purposes, including military. It may well be that an extra billion or two billion dollars spent annually on energy over the next decade would yield far more enhancement in our national security than a billion or two billion dollars in the defense budget.

The question that is most commonly regarded as political poison has to do with government revenues. I believe that American taxpayers are prepared to pay more taxes if they believe that the nation's security and its economic independence will be strengthened through research and development support for renewable energy. Of course, there are some persons or groups who contend that all dollars spent privately are more efficient and more productive and more fruitful than any dollars spent by government.

These are more politically motivated than economically relevant views. Dollars spent privately for cigarettes and alcohol and drugs are hardly more fruitful than dollars spent publicly for education and police forces and increased energy independence.

As far as specific energy research and development projects are concerned, I, as an economist, am not in a position to judge among alternatives, but I do have views on taxation and incentives and the like, having worked not only in the United States government, but also in many countries throughout the world in an advisory capacity and for many industries in the United States. Once there is a national awareness of our energy problems and the will to try to do something about them, we will not have too much difficulty in deciding what specific approaches to take and what technologies to support. I wish to emphasize strongly that it is of utmost urgency that we support not only basic research for discovering new sources and new technologies or improving existing technologies, but that we also support development efforts. That means helping in the production and manufacture as well as in basic research.

Thank you.

Senator FOWLER. Well, we won't vote on that today.

Mr. NATHAN. Those are my actions that I would suggest.

Senator FOWLER. Mr. Cooper would like to ask you some questions, and then I will follow up.

Mr. COOPER. Recognizing that we are operating with a limited budget, what criteria would you use to pick among these technologies if we had to pick among Ms. Fitzpatrick's children?

Mr. NATHAN. Well, first of all, I certainly would pick those technologies where you had the greatest degree of progress and where scientists and production specialists would feel that the greatest prospect is there. Now, having said what I did before, I would say very, very importantly, Mr. Cooper, that I think unless we are going to support the production side, the manufacturing side, the side where you get the product without a lot of investment, you are not going to get it.

I don't think we are going to get anywhere and I therefore feel that confining our help to the earlier stages is not going to be helpful. We ought to get something where we can begin to get results reasonably soon, as well as the long-run pure research.

Mr. COOPER. Is this a question of emphasis in funding R&D or is it a different kind of mechanism to get at the production side as opposed to the research side?

Mr. NATHAN. Well, I think on the production side, the tasks aren't so severely difficult. You have got to talk to the industry as well as the scientists, and I think that the solar energy people as I see it are very, very optimistic on the solar thermal and very optimistic on the photovoltaic.

Since they are likely to have very, very widespread participation, I would favor them very much but I would say also on that score that we'd better take a look at what our competitors abroad are doing to help their industry because I agree with the implication of a question that was raised to the Secretary and that is that the photovoltaic capabilities of the Japanese have improved tremendously and they are building capacity far beyond what we are.

I think that the industry is getting tremendous help and support which it ought to have in the government, and I do not think we are giving that kind of support.

Mr. COOPER. What are they doing that we do not do?

Mr. NATHAN. A lot of the efforts of many of my associates in the economic field in trying to understand why the Japanese moved ahead of us so far and are moving ahead is not easy to explain. And by the way, I would emphasize that relationship whereby they are doing well is more on the production side than the technology side.

We are still ahead in technology.

Mr. COOPER. They are using our technology in many cases.

Mr. NATHAN. I think what they are doing is, they are far more liberal in the government in terms of concessionary financing, in terms of incentives for training and education, in terms of development side of research and development, and there are a whole variety of those techniques.

And we are concerned about them but they do help their exports, maybe not as much direct to the United States because we are complaining so bitterly about our trade balance being so lopsided, but every indication, of those I know who have studied the Japanese economy, indicates the government is playing an important role in giving them that capability.

Mr. COOPER. So, we are thinking then about mechanisms like we have in this country with Public Utilities Regulatory Policies Act. Rather than stimulate research directly in alternative technologies, we provide a market and let the technologies come forward to serve that market?

Mr. NATHAN. Well, I certainly think we ought to provide a market. You know, take the solar energy that has been very important in the space program for the craft, crafts that are out there and I think that the government might well take a very important step. The solar energy people feel that the Department of Defense, as distinguished from the NASA, has not taken advantage of this and is not buying and is not ordering.

Marginally it may cost them a little more at this time but in the long run it could be very beneficial and I think that is the kind of long-term attitude and perspective that is terribly important.

Mr. COOPER. Do you think it is a question of attitude or is new authority needed to have a program like that?

Mr. NATHAN. Well, it's very hard to say. I am very respectful of Armed Services and I am also very supportive of a strong America, but that doesn't mean that every dollar spent in the military side is spent wisely.

In World War II we had plenty of problems. It wasn't always the civilians who were right, or industry was right. But there are differences in views, and I think that the energy industry—I mean, the Defense Department procurement people in the planning shouldn't be the only ones that make judgments about what adds to security.

In my judgment, if we can minimize, reduce our reliance on import at all, which probably is going to push our balance of payments adversely by $30 billion to $50 billion a year within five years from now, and I think if we can say to the Department of Energy, look, you can help overcome this national economic problem which weakens our country from a security point of view, buy more, help develop the market, I think that is important government policy.

Senator FOWLER. Since you raised the question of the oil imports, what are the merits and demerits if the choice was an import fee as opposed to a 10 or 12 cent increase in the gasoline tax?

Mr. NATHAN. I think the gasoline tax would be a very, very attractive alternative although frankly, Senator, I think both may be essential. One of the tragic things that has happened, I think we have forgotten about conservation, the bigger cars, longer mileage, what is the difference? It only costs, you know, 82 cents a gallon instead of $1.30. It used to cost twenty-five.

But, I think that conservation is a very important element that can be derived from an import fee. I think the added revenue would help in terms of our fiscal problems. I think most important of all, however, is that if we were to stabilize it and avoid this big up-and-down, because actually the fluctuations of oil from $3 a barrel to $14 to $28 to around $37 peak and back down to $10, has had a kind of a wild effect on our investment policies and our expenditure programs.

I think it is a stabilizing factor, but also I think we increase our drilling for finding new resources of oil and gas which we are not doing now—drilling this past year was down to about a seventh of what it was about three years ago.

Now, it is disadvantageous in a sense that it is going to cost the consumer more, but I think there are other alternative revenue sources that would be just as burdensome on the user as this, and wouldn't have the benefit in terms of conservation that the import fee would.

Senator **Fowler**. Mr. Nathan, we thank you for your testimony.

Mr. **Nathan**. Thank you, sir.

Senator **Fowler**. For our last panel today, we welcome Mr. Roger Little, President of the Patriot Squire Corporation in Bedford, Massachusetts.

We welcome Mr. Robert Sherwin, the President of the American Wind Energy Association from Connecticut; and Mr. Patrick Francois, Vice President, LUZ International, Los Angeles.

Gentlemen, we have your statements and I will make them part of the record in their entirety. You may either summarize your comments in reaction to what has been said, as well as any points that you would like to make.

Mr. Little, we will start with you and go down the line.

STATEMENT OF ROGER G. LITTLE, PRESIDENT, SPIRE CORP., AND VICE CHAIRMAN, SOLAR ENERGY INDUSTRIES ASSOCIATION, PHOTOVOLTAICS DIVISION

Mr. **Little**. I would like to summarize my comments.

Senator **Fowler**. We are very pleased that all of you would take the time to come and share your time with us.

Yes, sir.

Mr. **Little**. My company is Spire Corp. We are in the photovoltaics business. It's a small company. We have about 165 people. We have been in photovoltaics for about 15 years and during that period of time we have seen the course of the technology development, research and development as well as the industry.

Right now we see continued shrinking budgets in Washington and the results have been, over the past four years, that it has really driven a lot of small businesses out of photovoltaics. Even the big oil companies are stepping back, wondering whether they should be in photovoltaics.

At universities we can no longer get students who want to study photovoltaics, so that they no longer are ready to enter into the job force, and government labs have lost interest. They pursue much more exciting things such as Star Wars. Things have changed a great deal since 1982 when the budgets were about $160 million.

Our expertise is to develop technology and then to manufacture machines that manufacture photovoltaic cells and modules.

We are in the equipment business, and we have equipment all over the world and our map is over there, and it's in about 20 different countries and I think it's important to note that four years ago we were shipping about an equal number of machines overseas as putting in the U.S.

Now, we are shipping at the rate of about eight to one overseas versus the U.S. So, the U.S. industry has really dwindled and there is a tremendous lack of interest in photovoltaics in the United States.

You have heard, and we support the importance of photovoltaics for utilities. I work with New England Electric which is in Massachusetts, and if their projections are correct they need a great deal of energy from new sources in the early 1990s. Massachusetts won't let nuclear plants go in. Massachusetts is very negative on oil-burning utility plants because of the environmental impact.

We have very few choices left. We can get hydropower from Canada, but we have to deal with renewables. New England Electric is very concerned, and I think they represent utilities throughout the country.

We're getting a lot of competition from overseas, and you have heard all the countries, Japan, we know how aggressive they are. You might note that Italy's budget for photovoltaics now is approximately equal to what OMB is recommending for photovoltaics to the Department of Energy.

Italy—we have come a long way over the years. We have made a lot of progress. We have developed plans as a county which involve like 60 million dollars' worth of resources, and you know they have been down around forty but we've still made progress.

I think it is important, and I take the opportunity to point out one of the things that we have done at Spire is make a module like this. This is a 15 percent efficient photovoltaic module which is a DOE goal.

So, the technology exists to achieve very high efficiency. Now, to get the cost down, we really have to get into manufacturing technology and as has been noted, there's absolutely no resources available to help take these test tube technologies out into the real world.

Senator FOWLER. To what do you attribute what you have described a moment ago as the lack of interest in photovoltaics?

Mr. LITTLE. At the Department of Energy level or——

Senator FOWLER. I don't want to put words in your mouth. At the Department of Energy level or anywhere else.

Mr. LITTLE. Well, in the Department of Energy I think they're still going by the initial Reagan guidelines of basic long-term, high-risk research, and that indeed does not carry you very close to the marketplace. I think that is what we are going to have to overcome if we are really going to continue to keep our technological lead, technological lead and more into the marketplace.

Technology is very important. If you have a leadership in technology, in a product, people find you from all over the world. They find you from Pakistan. They find you from New Guinea. You don't really have to do a lot if you've got the best technology and the best product.

Senator FOWLER. Are we still ahead technologically? Do we still have the technological edge in photovoltaics?

Mr. LITTLE. I think in some areas we do indeed have a technological edge over the Japanese. But in most cases, maybe 80 percent of the cases, we are equivalent but the Japanese have been able to move closer to the marketplace because of the consumer products previously mentioned which allowed them to build up their manufacturing capacity, which has not happened in the United States.

The photovoltaic industry is small, $250,000 a year. If you take ten percent of that and say you can afford to have an R&D budget as a whole industry, worldwide industry, you only come up with about $20 million or $25 million. But, we know the rest of the world is spending at a much higher rate.

I think it is important to note that in the recent pasta we have had Sohio, Exxon, Chevron, Phillips Petroleum, all drop out of photovoltaics, and there are only two oil companies remaining. But in that period of time which they were in photovoltaics, many more people dropped out so that the remaining industry now is very shaky and very small.

We need a lot more support in R&D. We need at least $40 million this year. I mentioned I had been in this business now about 15 years. Over the past four years it's been sort of a spring ritual to come down here and fight for these dollars and I hope that we don't have to continue to do this.

One of the results is, it just jerks the whole system around, the people participating, and there is really a tremendous disenchantment with photovoltaics. I think we need to add to our basic—to the R&D budget that we have seen over the past few years and we need to add in a line called "Manufacturing Technology." Let's get this stuff up to a level at which we can produce some products and get it out of the lab and compete.

I really believe we have got to come back in maybe 1988 or 1989 and start to look at at least $100 million a year budgets instead of this $20 million that we keep getting down from OMB. So, that summarizes my comments and I thank you. I would be happy to answer questions.

[The prepared statement of Mr. Little follows:]

MP-87-06

Statement of

Roger G. Little
President
of
Spire Corporation
and
Vice Chairman of
The Solar Energy Industries Association
Photovoltaics Division

Concerning

PHOTOVOLTAIC INDUSTRY RESEARCH AND DEVELOPMENT NEEDS TO INSURE AMERICAN ENERGY SUPPLIES AND INTERNATIONAL COMPETITIVENESS

Before the
Subcommittee on Energy Research and Development
of the
Committee on Energy and Natural Resources
of the
United States Senate
Washington, DC

March 24, 1987

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1.0 INTRODUCTION

Photovoltaics, the technology for the direct conversion of sunlight to electricity holds great promise as a contributor to our basic energy supply as well as an American high technology export industry. Even as this promise becomes more clear, the dwindling American photovoltaic community is faced with significant difficulties in maintaining technological leadership. The resulting impact of these difficulties could cause our nation to lose momentum and the strong worldwide position we have obtained with photovoltaics technology. It could also result in providing foreign nations with the opportunity to dominate the American domestic photovoltaic energy market as it develops. Expanded research and development and a strengthened government industry partnership are keys to remaining competitive in the international photovoltaic energy market.

The purpose of this statement is to state concisely:

(1) The current opportunities for America as an international competitor in photovoltaics,

(2) The technological progress the American industry has made to date,

(3) The likely effects of foreign competition on the American photovoltaic industry, both here and abroad

(4) The need for the American government commitment to the advancement of photovoltaics through a significant continued sponsoring of research and development effort.

2.0 PHOTOVOLTAICS IS A HIGH TECHNOLOGY EXPORT INDUSTRY

The demand for electricity in developing countries, which lack established utility grids, gives photovoltaics the potential of becoming a large-scale export commodity. For the seventy percent of Third World citizens who live in rural areas, electrical energy availability is a major problem. An accessible source of electricity is needed for health care, rural electrification, and agriculture. Photovoltaically powered water pumps, medical refrigeration, electric lights, and television receivers have been widely but sparsely deployed. These stand-alone systems have been used to educate, improve the health, raise the standard of living, the productivity, and improve the overall quality of life and the self sufficiency of people throughout the world.

The United States, India, Italy, France, Japan, Germany and the U.S.S.R. and others are supporting major research, development, and commercialization efforts in photovoltaics technology. Several foreign nations - notably Japan, Germany and France - have listened to the requests of developing countries for access to this appropriate technology and routinely supply photovoltaic equipment as part of foreign aid programs. Foreign competitors have made major inroads in the international marketplace. In addition, the Chernobyl disaster has raised photovoltaics to a priority energy source in Europe.

3.0 PHOTOVOLTAICS CAN REDUCE AMERICAN RELIANCE ON FOREIGN ENERGY SOURCES

Although oil prices have dropped over the past two years, electricity prices have not. Many American utilities are at a critical crossroad as they confront an uncertain future demand for electricity. Large conventional capacity additions required for their economies of scale pose considerable financial risks to the industry. Photovoltaic technology, however, has proven itself to be ideal for adding dispatchable generating capacity in the required incremental quantities. The fact that photovoltaic energy production has minimum environmental impact is an important attribute for utilities, their regulatory commissions, and concerned citizens.

Photovoltaics can reduce our nation's dependence on foreign oil imports. Photovoltaic production requires no off-shore components, and once installed, photovoltaic arrays require no fuel and little maintenance, thus making such power sources immune to fluctuating oil prices. The present relative calm is the ideal time to carry forward research on this technology, as Japan and other nations are now doing.

4.0 DANGER OF AMERICAN PHOTOVOLTAIC NEEDS BEING FILLED BY FOREIGN IMPORTS

Should our government and our industry not meet the research, development, and commercialization challenge, photovoltaics as a successful and mature technology could become a major import rather than an export product. Although America now holds a leadership position in the technology, the Japanese are aggressively pursuing commercialization based on America's research. In order to survive, as American research budgets have been reduced, many American companies have sold the only product that they had market-ready, the know-how itself. We cannot allow our investment in this technology to be dissipated. We cannot allow the Japanese to dominate yet another American industry. Kyocera and Hoxan, two Japanese companies, are now aggressively marketing photovoltaic products in the American

5.0 AMERICAN PHOTOVOLTAIC TECHNOLOGY PROGRESS

The photovoltaic community began working on the research program necessary to achieve significant manufacturing cost reductions more than ten years ago. During the last decade, significant technological progress has been made resulting in cost reduction by three orders of magnitude, reliable PV products and thousands of new applications. More recently, the photovoltaic industry and research community, working closely with DOE, universities, government laboratories, and electric utilities, has contributed to the development of the DOE Five-Year Research Plan. The Plan's ultimate objective is a reduction in the price of electricity generated by photovoltaics. The Plan identifies the research needed to establish the technology base for large scale commercialization of photovoltaics. Industry, universities, government laboratories, and electric utilities have adopted this plan and are now making exceptional progress toward these common goals, including:

(1) Efficiency - photovoltaic modules will be produced with greater than 15 percent conversion of sunlight to electricity.

(2) Endurance - photovoltaic modules will operate reliably for more than twenty years.

(3) Manufacturability - the feasibility of low cost production is now being established.

As a demonstrated measure of progress, the industry's manufacturing cost, which is reflected in product price, has dropped more than an order of magnitude since terrestrial photovoltaics research initiatives began ten years ago. However, cost must be reduced by at least another factor of five to have large-scale utility impact. This reduction will only come through further aggressive research.

6.0 AMERICAN PHOTOVOLTAIC INDUSTRY COMMERCIALIZATION STATUS

Although the PV markets have grown at a greater than thirty percent compound growth rate over the past ten years, they are still very small. Worldwide revenues for 1986 are estimated to be only $250 million.

The United States' lead in solar energy technology is being threatened more than ever by foreign competition. The current American market share of the worldwide photovoltaic market is 35 percent, down from 75 percent in 1980. At the same time, the Japanese market share has risen from 15 percent in 1980 to 46 percent at present. In part, this is due to the fact that competitors such as Japan have been aggressively pursuing overseas markets and developing commercial technology. Foreign competitors such as Japan often rely on active government support which encourages and subsidizes the development of photovoltaic technology. In addition, foreign competitors have strong government support for research and development which allows them to develop and commercialize state-of-the-art technology. This threatens the American technical status in the international marketplace.

As a result, the American photovoltaics industry has shrunk over the last two years and is currently under great stress. Once dominated by oil companies, almost all have dropped out becuase of lower conventional energy costs. Most recently Mobil Solar has stopped commercial production of modules and Solavolt, a joint venture between Motorola and Shell Oil, has announced a withdrawal from photovoltaics entirely. In the recent past Sohio, EXXON, Chevron, and Phillips Petroleum have abandoned initial heavy investments in photovoltaics. Of the oil based industry only Arco Solar and Solarex, a subsidiary of Amoco, remain.

Consequently, the modest private American industry cannot afford to support the research base necessary to bring the technology to the next cost-performance plateau. Continuing government help is mandatory to develop the scientific foundations upon which a large-scale industry can grow. If our government does not meet the challenge of supporting this industry, America could lose out as photovoltaics becomes a successful and mature product in the international and domestic market.

7.0 RECOMMENDATIONS FOR DOE R&D

American firms have been on the leading edge of efforts to improve the efficiency and reduce the cost of materials used in generating photovoltaic energy as well as technological innovation. They have continually incorporated improvements in manufacturing technology and equipment.

However, the weakening industry is losing ground. It needs substantial government help. We have seen the DOE photovoltaics R&D budget decrease steadily from $160M in FY 1982 to $40M in FY 1987. The OMB is recommending further reductions to $20M in FY 1988, because they now view photovoltaics as "commercialized." The oil company dropout rate tells a different story.

Also with these budget reductions and more of the large companies participating in the DOE Contract Research Program, universities and small innovative companies are participating less. Small business has proven itself in research, development, and commercializing technology and advancing the product into the marketplace.

Based upon these considerations, SEIA strongly recommends no further downward revisions in the $40.4M FY 1987 DOE R&D budget, which is critical in continuing the research momentum, but that $6M more be added for utility scale experiments. The FY 1988 budget should be enhanced to $65.6M including $7.5M for utility scale experiments which are neded to assess the newly-evolving technologies. Finally, FY 1989 should have a major budget allocation for manufacturing technology to aid in large scale commercialization. A $100M FY 1989 budget which is needed for scale-up of the laboratory technology toward the development of manufacturing technology, is therefore recommended. This is not excessive when weighed against the contribution that photovoltaics can make to our nation's energy picture and international competitiveness - both national priorities. These budget recommendations are summarized in Table I.

TABLE I. PHOTOVOLTAIC INDUSTRY RESEARCH AND DEVELOPMENT BUDGET NEEDS

($ MILLION)

	FY 87	FY 88	FY 89
Materials Research			
Amorphous Silicon Thin Films	$11.4	$12.5	$15
Polycrystalline Thin Films	5.0	5.5	7
High Efficiency Research	8.7	9.0	10
PV Fundamental Research	6.4	12.0	15
Manufacturing Technology	-	-	25
Collector Research	5.6	9.0	10
Technology Transfer	2.3	5.0	5
Research Equipment	1.0	5.0	5
Utility Scale Projects	6.0	7.5	8
TOTAL	$46.4M	$65.5M	$100M

Senator FOWLER. Thank you, Mr. Little. Next we will hear from our other participants, and then we can take questions.

We now have Mr. Robert Sherwin of the American Wind Energy Association.

STATEMENT OF ROBERT W. SHERWIN, JR., PRESIDENT, ATLANTIC ORIENT CORP., AND AMERICAN WIND ENERGY ASSOCIATION

Mr. SHERWIN. Thank you very much, Senator. I too have been in my industry as long as Roger has been in his, about 14 years, and I have watched the wind industry grow from $250,000 in sales in 1974 to almost $600 million in sales in 1985.

I think what I would like to point out in my comments, rather than reiterate the testimony which you have in writing, is some points about the status of our industry and where I think our strengths and weaknesses are.

One point to be made clear is that our organization, the American Wind Energy Association, represents a tremendous number of companies, 150 or so, nationwide. Even though 90 percent of the installed capacity for wind energy happens to be in California, a tremendous amount of the industrial support for this power plant occurs elsewhere in the United States, and I will give a few examples: towers in Illinois, Nebraska and Texas, blades in Michigan and Rhode Island, steel in Alabama, transmissions in Indiana, generators in Wisconsin and New York, machine shops in Maine, Connecticut and Massachusetts, fiberglass components from Rhode Island and California, brakes from Kentucky, Minnesota and Connecticut and so on. So, I do want to dispel the image that all of the effort goes straight to California.

The status of our industry is poor. Manufacturing in this country is way off and the manufacturing base from over 70 companies, albeit many of them small operations in the early 1980's, is down now to less than ten, very few of which are financially healthy.

However, in addition we have developed some very strong companies in project finance and project development abilities, resource assessment abilities, components manufacturing and operations. These particular skills will prove to be important as the rest of the world hopes to develop wind energy.

We were hard hit, primarily because of the loss of the tax credits. Ninety percent of the federal support which we got either directly or indirectly has gone in one year.

Our industry is undercapitalized. It always has been undercapitalized. I have made some estimates showing that we did about $1.2 billion with less than $60 million in equity in the whole industry, half of which was in one company.

Our competition from overseas has been very strong, partially because of the relationship to the dollar in foreign currencies at the time which worked against us, at the time when the tax credits were in place, and additionally the hand-in-hand effort on foreign governments, particularly the Danish, the Dutch. In bringing in imports in this country, we are competing against subsidized funds and long-term loans from governments for inventory financing, for manufacturing.

Lower fossil fuel costs, Mr. Nathan has addressed that issue. I won't dwell on that. We have had a significant number of regulatory problems, both local and national, and now we are told that PURPA might be under some hope of revision by certain parties.

Also, importantly, the federal money in the past, some $360 million into the wind program in the last ten or 12 years, a tremendous amount of those funds went to large megawatt scale machines, none of which are in the commercial marketplace, and to companies, none of which apparently are going to be in the commercial marketplace.

In spite of that, I would like to point out that wind does work. We have an installed capacity now greater than any nuclear power plant, over 1,300 megawatts in California alone. Our technology is getting better. Our capacity factor is up. Our performance factors are up.

The U.S. technology in particular, we are very, very strong in materials, electronic controls, and especially the critical area of aerodynamics and the understanding of the aerolastic and structural loads and wind turbines.

Also, the falling dollar has hurt companies wanting to import into this country, and also strengthen our hand for exports. We have made, as I pointed out, tremendous performance improvements.

In many situations, wind is very cost-competitive in many places in the country because we have no fuel costs. And one item which has been brought up is that we can add to power plant capacity on an incremental basis, in a matter of months megawatt by megawatt as opposed to 10- or 12-year powerplant planning for coal or nuclear, and where you have to come in with at least 600 or 500 or 1,000 megawatts at a time.

What do we need to be successful? We need continuation of specialized research for the near term, things that we need to get to the marketplace, and I support Roger's comments on that, this long-term looking for the year 2000 research is important, but if we are going to have an industry to make it to then, we need stuff that's going to help right now.

We need more capitalization within the industry. Wind, took has lost major players. Big companies such as Bendix——

Senator FOWLER. May I interrupt you there, Mr. Sherwin?

Mr. SHERWIN. Yes, sir.

Senator FOWLER. What would be the specifics of a government directed effort at moving wind and photovoltaics into the marketplace?

Mr. SHERWIN. Well, I had a comment with a gentleman from Montana here earlier, and one of the areas, I think where the government could be very useful is using its purchasing power to truly buy equipment for its own use for long-term projects.

As you know, we had the Wind Energy Act in 1980 and the Defense Procurement Act, I believe, of 1981 which specified the utilization of alternate energy in places where it didn't impact our security and where it was cost-competitive. In terms of actual procurements on the street, to American companies to provide equipment and expertise, there has been very little.

I think that is one area which is not tax oriented but procurement oriented. It puts a meaning behind that, and some purchase orders, basically.

The second area, I think is in terms of developing our ability to export. We have the ability to do well in the export business in our technology, in wind, because our equipment is up to eight times lighter than the equipment manufactured in Europe.

So, when it gets down to pounds per dollar per kilowatt, we're going to be able to deliver. We need a little more research in the specific loads and structural materials area.

Second, I think we need a more direct cooperative effort between our government and our industry in competing in the overseas marketplace, and I think the last issue is, we need to have some long-term stability in planning so we know how to plan from year to year our businesses, related to what the long-term goals are for national energy policy.

It changes every year. The price of oil goes up and down. The price of electricity changes with the price of oil. And we just have no economic touchdowns to base a legitimate business plan that we can go to the capital marketplaces and convince them we are going to be in business in two years.

So, obviously we would like to see some tax incentives, but there are other mechanisms to accomplish the same goal which I don't think are necessary from a tax point of view.

Senator FOWLER Thank. you, Mr. Sherwin.

[The prepared statement of Mr. Sherwin follows:]

TESTIMONY OF ROBERT W. SHERWIN, JR.
PRESIDENT
ATLANTIC ORIENT CORPORATION
AND
AMERICAN WIND ENERGY ASSOCIATION
BEFORE THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
UNITED STATES SENATE
March 24, 1987

Mr. Chairman and members of the subcommittee, my name is Robert W. Sherwin, Jr., and I am President of Atlantic Orient Corporation of Norwich, VT, and also of the American Wind Energy Association (AWEA). We appreciate the opportunity to testify.

AWEA is a trade association which represents the manufacturers of wind electric turbines and components. About 150 companies are members of AWEA. While many are small businesses, a few large integrated corporations such as Boeing Aerospace Corporation are also among our members.

My testimony today basically revolves around three points:

1. Despite a major setback last year — the decision of the Congress to allow renewable energy tax incentives to expire -- the American wind energy industry is continuing to develop an increasingly mature energy-producing technology.

2. Because of the perception that America's energy problems are over, our industry is entering a critical phase of perhaps several years during which its survival is at risk.

3. A balanced, moderately aggressive federal wind research program is essential at this time, and our Association is working closely with the Department of Energy to ensure that its program is properly directed and relevant to industry's needs.

I would like to elaborate on these points.

1. Despite a major setback last year — the decision of the Congress to allow renewable energy tax incentives to expire — the American wind energy industry is continuing to develop an increasingly mature energy-producing technology.

Our industry absorbed a major blow in 1986 when the Congress decided not only to allow the 15% renewable energy investment tax credit to expire, but also at the same time to repeal the basic 10% investment tax credit.

This decision probably would have destroyed the wind energy industry in the United States if the economics of the technology had been less promising. Like other renewable energy technologies, wind energy suffers from a high initial capital cost compared to conventional energy technologies, and the investment credits were an ideal incentive.

As it is, the pace of wind energy's growth slowed sharply. The total capacity of new wind turbines installed in 1986 dropped to about 200 megawatts (MW) from approximately 500 MW in 1985, a 60% reduction after four straight years of exponential growth. We expect about the same total -- 200 MW -- to be installed this year.

The total number of new turbines installed sustained a similar drop, to about 2,000 from about 4,000 a year earlier, and new capital investment also dropped, to approximately $200 million from an estimated $750 million in 1985.

Nevertheless, our Association continues to see indications that wind energy technology is continuing to mature:

- o Energy production per kilowatt (kW) of installed capacity rose from 660 kilowatt-hours (kWh) in 1985 to an estimated 980 kWh, an increase of nearly 50%, and a further substantial improvement is expected this year.
- o Productivity per turbine also rose, from 75,000 kWh in 1985 to an estimated 97,000 kWh in 1986.
- o At the end of 1986, our industry could look back with some satisfaction on a fifth consecutive year of increased capacity and increased productivity, which combined to bring about another massive jump in total wind electric power production. Total windfarm power output rose from 670 million kWh in 1985 to an estimated 1.2 billion kWh in 1986, an 80% increase.
- o About 2 million barrels of oil would have had to be burned to produce the same amount of electricity as the windfarms did in 1986, and by year's end, the cumulative savings from wind totalled nearly 4 million barrels.

- While the indicators of production climbed, wind energy's installed costs plummeted, dropping by nearly 50% in 1986.
- Since the "fuel" for a wind turbine is free, the operating costs (Operations & Maintenance costs plus fuel) for a wind power plant remain well below those for any conventional energy source.
- The total levelized cost of power from windfarms, at 7-8 cents per kilowatt-hour, has fallen below the cost of power from new California nuclear power plants, which is in the neighborhood of 11 cents per kilowatt-hour.

In short, after a decade of development and learning experience, wind energy continues today to look like one of the outstanding winners among the new energy sources which the Science and Technology Committee identified for targeting federal research efforts in 1974.

By way of background, I should explain here that wind energy's forward progress has not always been smooth. Harnessing the wind has proven to be a surprisingly difficult technical challenge.

The force which the wind creates on an object in its path is a function of the cube of the wind speed, so that the forces working on a wind turbine increase geometrically as the wind rises. Also, the wind is often very turbulent, changing direction and speed quite rapidly. For example, a doubling in speed and change in direction of 45 degrees in less than one second is not uncommon.

This high variability means that a wind turbine operates in a very difficult environment which was not originally well understood.

It was originally thought that the aerodynamics of helicopter blades and airplane propellers would be readily applicable to wind systems. That has not proven to be the case. Wind turbines are different and require very different airfoil shapes.

Early analyses also assumed, for lack of better information, that the wind's flow would be relatively smooth. That, too, was mistaken. The physical stresses which a wind turbine undergoes in actual operation were often several orders of magnitude greater than those predicted by engineers.

And finally, fatigue remains one of the most difficult and elusive problems in wind turbine design. Wood-epoxy laminates and composites are the materials of choice for wind machine blades, and little useful fatigue information is available even today for these materials.

2. Because of the perception that America's energy problems are over, our industry is entering a critical phase of perhaps several years during which its survival is at risk.

Despite the technological and commercial progress our industry has made, its survival today and in the near term is threatened by a series of unfavorable developments:

- Federal government support for wind energy has been dramatically reduced. The energy investment credit and the basic investment credit totalled approximately $200 million in support during calendar 1985, their last year of existence -- an amount more than 10 times last year's federal wind research and development (R&D) budget. Thus wind energy is unique among the renewable energy industries in having lost over 90% of the overall share of the federal budget which it held just over a year ago.

- Oil prices, after dropping sharply a year ago, have remained weak and are only now beginning to show some signs of recovering.

- The Federal Energy Regulatory Commission (FERC) has recently announced its intention to review certain key areas of the Public Utility Regulatory Policies Act of 1978 (PURPA), which guarantees windfarms a market for the power they produce.

- The Administration, for reasons with which we are all familiar, is continuing to propose drastic cuts in wind energy research at a time when other countries, in particular Denmark and the Netherlands, are increasing government support for their wind energy industries.

To these factors which are mostly outside our industry's control and which create doubts today about its future must be added one more.

Both American manufacturers and the U.S. federal wind energy program were strongly influenced initially by the notion that wind systems could be made most economical by incorporating advances in materials and aerodynamics from the aerospace industry.

Our chief world competitor, the Danish wind industry, chose instead to draw upon its own past experience in the use of wind machines as agricultural equipment, making them sturdy, bulky and heavy.

Thus American machines today tend to be much lighter and more technically advanced than Danish turbines. In fact, they typically produce three to five (or even more) times as much electricity per pound of material. However, because of the unexpected problems with the wind discussed earlier, they have also been much more prone to failure and have required substantially more maintenance.

Although it seems clear that American wind systems have the potential to be cheaper than Danish units, that potential is still some distance from being realized, and the higher reliability of Danish machines has made it easier for them to obtain financing.

As a result, Danish units, according to our estimates, accounted for nearly two-thirds of the new wind machines installed in 1986 in the United States.

Thus today, despite the fact that some hundreds of millions of dollars have been expended on wind energy research in the U.S., and despite the fact that the global energy situation today is no more positive than it was a decade ago -- and indeed, in some aspects, has deteriorated -- our industry's near-term survival remains an open issue.

3. A balanced, moderately aggressive federal wind research program is essential at this time, and our Association is working closely with the Department of Energy to ensure that its program is properly directed and relevant to industry's needs.

Last year in our testimony, we called for greater cooperation with the federal wind program, and I am pleased to report that the Department of Energy has responded.

In early December, AWEA's Research and Development Committee met for two days with wind program personnel and with representatives of the federal laboratories involved in the wind program to review current research projects and goals.

We had an excellent meeting with a lot of give-and-take, and we feel that significant progress was made toward our two key objectives, which were (1) promoting communication between industry technical experts and the wind program and (2) establishing industry's views on the most promising future directions for the program. Those views are reflected in the recommendations I am making here today.

We think the December meeting has laid the foundation for a much closer relationship between our industry and the federal program in the future, and we are looking forward to building a program that will maintain and, hopefully, extend America's lead in the technology of wind electric turbine design.

That being the case, we cannot endorse the Administration's proposal to cut wind energy research by approximately 50% to $8 million. As previously noted, total federal support for wind energy research and commercial development has been slashed by about 90% since the end of 1985, and research spending alone has been cut by more than 75% since the current Administration took office. We do not believe further reductions are in order.

Our recommendations to this Subcommittee call for approximately level research funding compared to last year, and we see this as a minimum figure for this program. At this level (about $17 million), wind energy, which could someday contribute as much energy to our national supply as hydroelectric power does today, will consume less than two one-hundred-thousandths (2/100,000) of the federal budget.

As to specifics of the program, our Research and Development Committee found the federal program's direction to be generally satisfactory. However, the we have identified several areas where we believe the research effort should be intensified and some other areas which we feel should have a lower priority.

Among our recommendations are the following:

(1) The federal program has devoted a number of years and sizable quantities of funds to development and testing of a variety of wind turbine designs. In addition, it has tested a number of different wind machine configurations (e.g., different numbers of blades, different blade materials, etc.) on government-owned testbed units like the MOD-0 machine in Sandusky, Ohio. However, we believe an insufficient amount of effort has been devoted to taking the results of all of this testing and reviewing them critically to determine what can be learned about the best directions for wind turbine design.

We therefore recommend **increased support for design tradeoff studies which would review existing research data and draw conclusions about the most promising wind turbine design concepts.**

(2) While the federal program has concentrated almost exclusively over the past decade on the testing of individual wind turbines, commercial development has been based on the "windfarm" concept, with large numbers of turbines being installed at the same geographical location. That in turn has led to growing interest in the degree to which the electric power produced by windfarms is, or is not, fully compatible with utility grid requirements. Since utility acceptance of wind electric turbines is a major long-term prerequisite for wind industry growth, this issue is central to the industry's future.

We recommend that **increased effort be given to power quality research, to ensure that electricity produced by windfarms is of acceptable quality for utilities, particularly in areas where the percentage of wind electricity on the local utility grid is high.**

(3) A key area of the current federal research program which has been producing highly useful information is airfoil research. Wind turbine power output can be significantly improved, and

maintenance costs lowered, if airfoil shapes can be found which are less affected by turbulence and surface degradation.

We recommend that **research spending on advanced airfoils be increased.**

(4) Another research area which has significant potential for increasing wind turbine power output and decreasing fatigue and maintenance is variable speed operation. Since the wind itself is variable, a wind turbine which can also operate at varying rpm will automatically experience less structural stress. Variable speed systems have been the most commercially successful of the very small (residential-sized) wind turbines, and it seems likely they would dominate at larger sizes as well if an economic variable-speed design could be identified.

We recommend **increased support for research on variable speed wind turbine generation.**

(5) The Solar Energy Research Institute (SERI) this year is beginning what is called the "Combined Experiment," which will look intensively at all aspects of operation of a single test wind turbine and attempt to correlate structural stress with wind inflow. If completely successful, it would allow us to find out exactly which wind conditions cause problems from a stress and fatigue point of view and to design for those conditions.

We recommend **increased funding for efforts to correlate wind inflow/turbulence and structural loads so as to identify key factors in wind turbine stress and fatigue.**

To maintain approximately level funding, we have also identified several areas where we believe spending can be reduced without compromising the wind energy research program, and those are included in the detailed budget recommendations which we will be providing to Subcommittee staff. We will also be advising staff of our detailed recommendations for funding at the level of $8.5 million requested by the Administration.

Again, we thank you for the opportunity to present our views, and we look forward to working with the Subcommittee to develop a sound and increasingly useful wind research program.

Senator FOWLER. First of all, let me bring in Mr. Francois and then I would like you to address that question.

Mr. Patrick Francois of LUZ International.

STATEMENT OF PATRICK FRANCOIS, EXECUTIVE VICE PRESIDENT, LUZ INTERNATIONAL LIMITED

Mr. FRANCOIS. Mr. Chairman, LUZ is a small company but in spite of that we are today the largest producer of solar electric generation equipment in the world with 100 megawatts of capacity already installed and another 400 megawatts of capacity already contracted for and to be placed in service over the next five years.

It is a pleasure to take this opportunity to share some of our experiences in running a company in the business of commercially making it, I would say, and selling solar electric generation equipment.

Very quickly, our technology differs from the photovoltaic technology which we have seen a lot of examples of here, by the fact that it involves an application of heat other than direct conversion of solar radiation to electricity.

This method of producing power is relatively identical to the technology used in other steam based power plants, most of them, in that it uses steam through a turbine to create kilowatt-hours. The only difference is the source of the steam which is used to drive those turbines.

At LUZ our goal has been to take solar technology from the research and development stage to commercial competitiveness, and with the help of the energy tax credits that have been extended to 1988, and which we have to be very appreciative of your efforts as you were a member of the House Ways and Means Committee, and thanks to our own productivity gains our technology has now become competitive with crude oil for electrical generation, for peaking facilities.

As the tax credits are being phased out we believe that we can remain competitive with oil as long as it is priced at anywhere between $15 to $20 per barrel. I would tend to agree with my colleagues here that there is no way we can survive with radical drops in the price of oil and anything which would be done in order to provide us with some kind of floor as far as energy prices would be helpful for all of our industry, I believe.

We also think that by being able to further reduce our costs and by taking advantage of additional economies of scale, we will be able to make our technology more efficient and to again be able to compete in a non-credit driven environment as long, again, as oil remains at over the $15 to $20 per barrel level.

We think that our experience in California has proven that solar thermal technology can be a reliable and economical source of power for electrical utilities, again for on-peak and mid-peak utilizations which happen to be the times at which West Coast utilities have their biggest demand for power.

I would like to emphasize that our technological development has been centered primarily on a reduction of the cost per square meter of our systems; second, in an improvement in their efficiency measured in kilowatt hours per square meter per year; resulting collectively in a net acceptable reduction in dollars per kilowatt hour of electricity produced, because for the power generation that is the only criteria which the market has been looking at so far.

The capacity of our solar field is delimited to 30 megawatts. We believe that at this point we have achieved most of the efficiency gains that are possible in a field that size.

Because efficiency and cost reductions could be achieved in both the power plant itself and its general operation and maintenance, if larger plants with substantial economies of scale could be deployed as a substitute for a greater number of smaller plants, while the total megawatts of installed capacity would remain the same, the cost per megawatt of installed capacity would be significantly reduced.

In a nutshell, a larger facility would produce three times the power at twice the cost if we were to triple the capacity of those existing plants.

Today, as we compete with current technologies and with existing credits, we have been able to successfully finance and develop those facilities, in the future as those credits are going away we are going to have again to scale up and we will need our freedom to attract capital equity for those larger facilities, which is something which we cannot do today because of regulation concerns.

I would like to conclude by saying that in general the future for solar thermal energy appears to us to be bright, and we hope that our company will continue to play an active role in breaking new ground in technology and business planning. We have made the transition from research and development for most of our technology.

There is only a limited number of research fields where we will be looking, conceivably, for federal support, and we think it is because of the help and support provided by the national energy policy which has targeted the development of energy technologies as a high priority.

We can be successful once those credits are gone, once direct support of R&D has gone too, if the Congress gives us the freedom to attract capital needed for larger projects in order to achieve the economies of scale needed.

Thank you.

[The prepared statement of Mr. Francois follows:]

Testimony of
Patrick Francois
Executive Vice President
LUZ International Limited

Senate Committee on Energy and Natural Resources
Subcommittee on Energy Research & Development

March 24, 1987

Mr. Chairman and members of the Committee, my name is Patrick Francois, I am the Executive Vice President of LUZ International Limited, the largest producer of solar electric generation equipment in the world.

Thank you very much for the invitation to testify at this hearing today. Your continued interest in alternative energy resources at a time of relatively abundant energy supply is farsighted and commendable. The Department of Energy issued a report last week that underscores the vulnerability of the United States to oil supply interruption, and the importance of keeping attention focused on alternative energy potential before another crisis develops.

It is a pleasure to take this opportunity to share some of my experiences running a company in the business of selling solar electric generation equipment.

Overview

The basic technology we use at LUZ is remarkably simple. We use the heat from the sun to boil water and we use the steam from the boiling water to run turbines to generate electricity. Our solar technology differs from photovoltaic technology in that it involves an application of heat rather than direct energy production.

This method of producing power is virtually identical to the technology used in other steam-based power plants, whether they run on fossil fuel or nuclear energy. The only difference is the source of the power to heat the water.

While solar technology will not work everywhere, it can be successfully employed under the right climatic conditions, particularly for meeting peak demands of electric utility systems. These conditions prevail throughout much of the southwest United States, in several Mediterranean and Carribean countries and in many energy poor and economically-distressed arid parts of Asia and Africa. We believe that this technology offers the potential of greater energy independence for the United States and many other energy-importing nations.

The benefits of lowering energy imports are clear in terms of both trade balances and energy security. A more stable domestic energy supply enhances the competitiveness of U.S. industries by reducing the risks of supply interruption and rapid price increases.

At LUZ, our goal has been to take solar technology from the research and development stage to commercial competitiveness. With the help of energy tax credits that will be phased out by 1989 and our own productivity gains, our technology has become competitive with crude oil for electric generation. As the tax credit phases out, we believe that we can remain competitive with oil priced at fifteen to twenty dollars a barrel and up, by further reducing costs and by taking advantage of further economies of scale to make the technology even more efficient.

At the present time LUZ has installed 103 megawatts of power at four plants in the desert of California for sale under a long-term contract to Southern California Edison Company. Attached to my testimony, Mr. Chairman, is a photograph of these facilities and a drawing showing how the plants work. Current plans and contracts call for capacity over the next decade to exceed a total of 500 megawatts. At that point, LUZ solar fields will have as much capacity as a small nuclear power plant and half the power of a large nuclear plant.

The LUZ experience in California has proven that solar technology can be a reliable and economical source of power for electric utilities, at the on-peak and mid-peak periods when utility customers need power.

History of LUZ

A brief history of the company's development from conception to this stage of our development may be useful. Our story of adaptation of technology and markets is probably not particularly different than many other alternative energy companies that were formed in response to the energy crisis of the 1970's.

Although LUZ is now exclusively in the business of providing power to Southern California Edison, that was not the original plan for the company. The company was founded in 1979 with plans to target the industrial heat market, but the economics of the solar fields in the late 1970's and demand for industrial heat proved to be poorly matched. We concluded that our solar technology was promising, but that industrial heat was the wrong application of the technology.

In 1982, LUZ shifted its business plan to the electricity generation market. This transition from industrial heat to electricity generation has been successful because our technology proved capable of meeting the necessary schedule and price requirements for long-term contracts with electric utilities.

Our transformation from developing experimental industrial heat plants to producing power for electric utilities was made possible by the tax policy and regulatory incentives enacted as part of the United States national energy policy in the 1970's. Much of that legislation was developed by this Committee and many of its members during their service on this Committee and in the House.

The business and policy climate for implementing the LUZ technology in this country was the direct result of a national commitment to encourage the development of alternative energy technologies. In 1978, Congress enacted an energy program designed to lessen the nation's dependence on oil and natural gas and to encourage the use of alternative technologies. This program included a series of energy tax credits applicable to the alternative technologies, as well as the Public Utility Regulatory Policies Act of 1978, which provided market and regulatory incentives for production of electricity from alternative energy sources.

LUZ Technology

With this background, I would like to share with you some of the details of the LUZ technology and some of the practical considerations for projects like ours, including particularly financing, which of course is essential for any further development.

In the 1970's and early 1980's, the Department of Energy funded basic research in solar technologies. One technology, the parabolic trough technology now used by LUZ, was explored for industrial heat uses. Another technology, central receiver technology, was explored for electric generation with the development of Solar One, supported by Southern California Edison Company and other utilities. Solar One greatly advanced the understanding of the proper integration of solar generated steam with the power block needed to generate electricity.

Based upon both areas of DOE-funded research, LUZ developed its technology for solar electric generation, using large parabolic mirrors to catch and focus the power of the sun on black pipes filled with synthetic oil. The oil is superheated by the sun and circulated through heat exchangers to produce steam to run our turbines.

The key to our efficiency gains to date has been increasing the amount of solar power that can be captured per square meter of mirror so as to increase the operating temperature of the working fluid in the solar field. The specific design criteria of the solar collectors have been carefully adapted to maximize the efficiency and minimize the cost per square meter and the need for maintenance. The first generation of our solar collectors, had an aperture area of 128 square meters apiece. The second generation of solar collectors are twice as large. Beginning in 1987, a third generation of even larger solar collectors will be installed. As a result of these improvements, the cost of the solar field has decreased from $2150 per square meter in 1981 to a projected $160 per square meter by 1988.

The capacity of our solar fields is now limited to 30 megawatts. At this point, we believe that we have achieved virtually all of the efficiency gains that are possible in a field that size. Further efficiency could be achieved however, in both the power plant itself and in the general operation and maintenance of the solar field and power plant, if larger plants with substantial economies of scale can be deployed as a substitute for a greater number of smaller plants. While the total megawatts of installed capacity would remain the same, the cost per megawatt of installed capacity would be significantly reduced, and the efficiency of the plants would be improved and the cost of production for each megawatt/hour of power produced would decrease.

The development of LUZ technology from the beginning has been an example of international cooperation. The technology was developed in the United States and Israel; the plant engineering, construction and financing are American; the materials that are used in our plants come from West Germany, Italy, Japan and Brazil, as well as from the United States and Israel. We hope to develop a U.S. export market for project engineering, management and construction services in conjunction with international materials contracts.

Meeting Capital Needs

One of the largest tasks that faces LUZ, as is true of every developer of a new technology is project financing. The challenge in the past has been to provide adequate return for the investing community by a combination of tax incentives and cash distributions from the investment. Because of high initial production costs and high perceived risk, the tax incentives were essential to attract capital from institutional investors. We believe that development of these projects have now become an acceptable risk for traditional financing which will greatly assist LUZ in moving forward more rapidly with future projects. Long-term debt appears to now be feasible, whereas up to this point, non-recourse debt was held by LUZ which meant LUZ would only receive funds on notes from project revenues.

This financing program has been successful in large part due to the quick turnaround in the construction schedule. Less than one year after ground-breaking, electricity was being produced at our newest plant which was placed in service last year.

An essential ingredient in our financing, however, is solar power's exemption from the Public Utility Holding Company Act of 1935, which results from Federal Energy Regulatory Commission regulations implementing section 210 of PURPA.

The exemption from the Holding Company Act means that our investors, as is true for investors in other alternative energy projects, need not comply with burdensome utility regulations that, among other things, limit their holdings in other businesses. Large companies whose business is not electric power generation are obviously unwilling to become partners in relatively small solar energy plant financing projects if that would require the divestiture of their primary business.

Today, this exemption only applies to projects that do not exceed 30 megawatts in size. In the future, as we attempt to scale up our projects to gain the efficiencies that are essential to survive in an environment of lower crude oil prices and no tax credits, our freedom to attract capital from a wide range of investors will be essential to our future competitiveness.

The future for the LUZ technology, we hope, will include more conventional financing and sales terms. Now that the technology is proven, we are hopeful in the long-term future that utilities will buy the technology itself to meet their own peaking needs. In fact, we are presently for the first time exploring with a utility the possibility of direct sales of LUZ equipment.

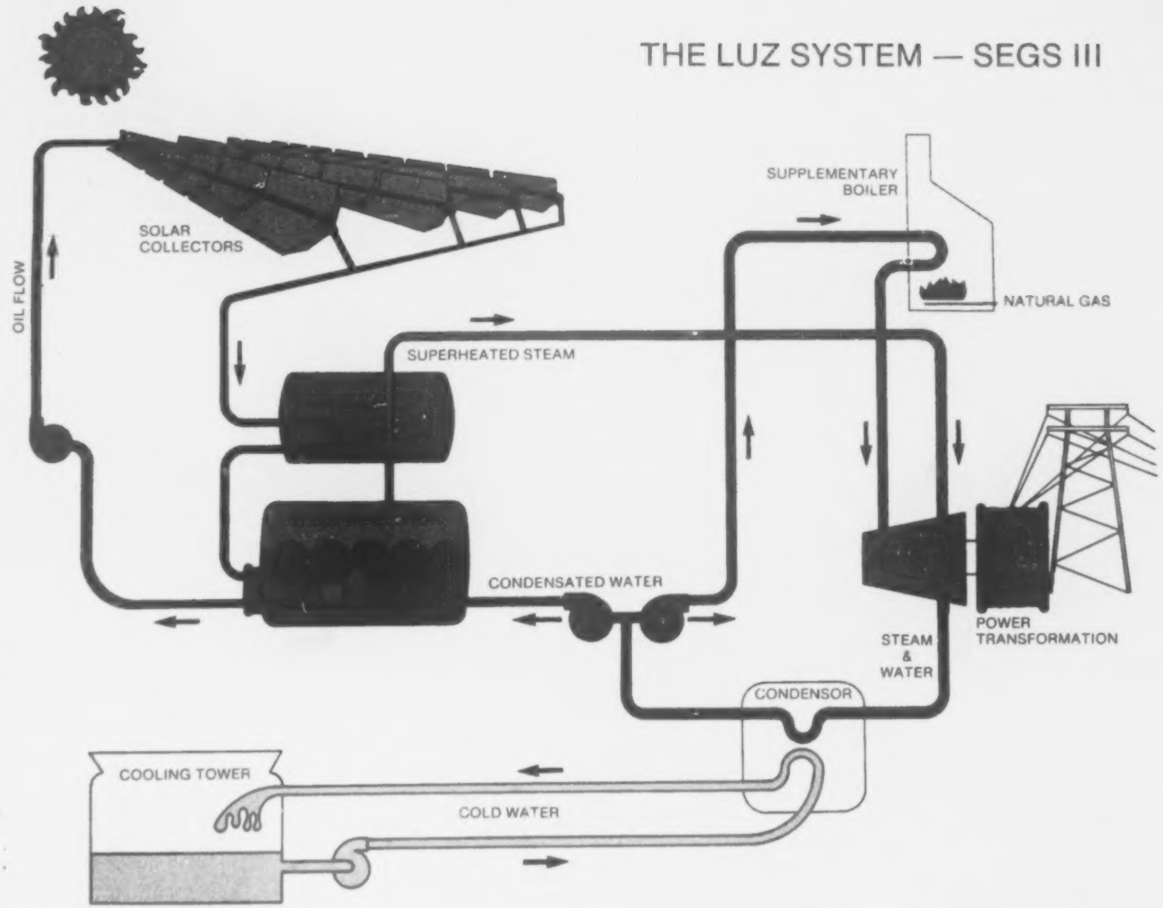
Conclusion

In general, the future for solar energy is bright and we hope that LUZ will continue to play an active role in breaking new ground, both in terms of technology and creative business planning. We have made the transition from research and development to commercial application with the help and support of a national energy policy that wisely targeted the development of alternative energy technology as a high priority. We can be successful in the future as well, if the Congress gives us the freedom to attract the capital that is needed for projects large enough to achieve the required economies of scale.

We are extremely hopeful that the transition now underway to become competitive in the post-energy tax credit environment will be successful. We look forward to your continued interest and support.

Thank you very much.

THE LUZ SYSTEM — SEGS III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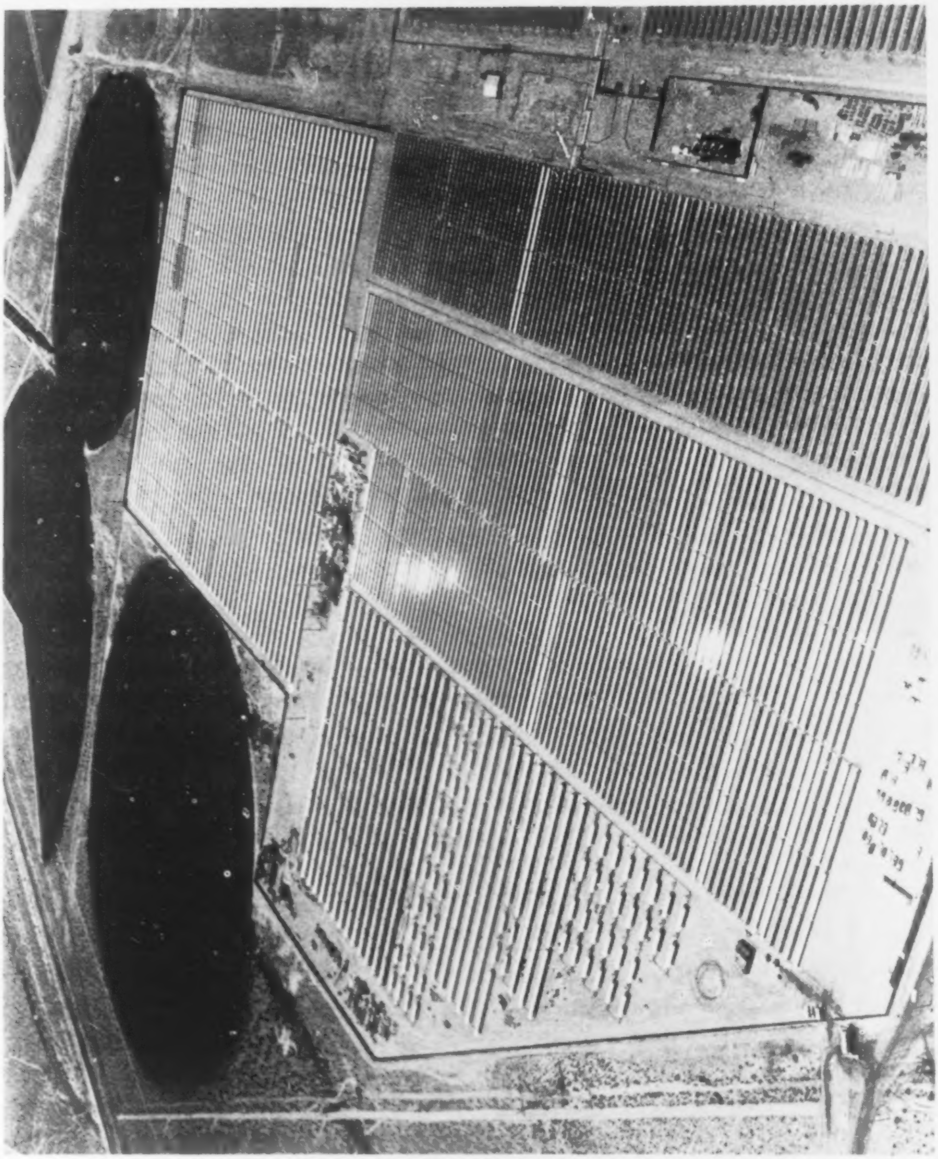

Senator Fowler. Mr. Little, I take it you would disagree with Secretary Fitzpatrick's analysis of the photovoltaic program, in regard to our national needs.

Mr. Little. Yes, I would. I think, to answer the question you raised earlier which is, what should the DOE do now, I believe that you have to revisit what was happening in 1980–82, and at that period of time there were three major components to the DOE program. One was advanced research and development which is all that remains today.

The second was technology development which was run by the Jet Propulsion Laboratory, and that took the best ideas from Advanced Research and Development and moved them into a state where more engineering work could be done to move them toward production.

Third, there were experimental demonstration programs, and so today where we look at a $40 million budget, principally assigned to advanced research and development——

Senator Fowler. They're cutting that to 20.

Mr. Little. They want to cut it to 20, yes, which is—I would just as soon not think about the number, but in 1982 it was like forty, forty and forty, advanced research and development, technology development and demonstration.

Senator Fowler. Right.

Mr. Little. And this PV–USA is a good example of what belongs in the demonstration part of the DOE budget. That kind of thing should be restructured and re-initiated.

Senator Fowler. Anybody else want to make a comment before Mr. Cooper asks some questions?

Mr. Cooper. Can you give us some specifics as to how you want to concentrate federal effort at nearer the market end than the research end? That seems to be what everyone is saying here, that you were glad to have the long-term, high-risk research support but that something else is needed.

We are going to try and respond to that in Congress. What are you going to have us do?

Mr. Little. Let me just try to say what I said before, a little more clearly. Advanced research and development is fine, but now we need to go into technology development which is to demonstrate manufacturability of these very small, in some cases square centimeter results through the development of new machines, higher throughput machines, more efficient machines and processes.

Third, we then need to go forward with some experiments on systems to show that indeed they do perform to our expectations.

Mr. Cooper. You are really looking for the Congress, then, to give some direction to the Department to have some emphasis in this area, as well as to provide more funds, because I get the strong feeling that twenty million is a disaster level for the program?

Mr. Little. In photovoltaics, $20 million is a disaster number and I think it would probably really put the country out of the photovoltaics business if it were to go forward at $20 million.

Mr. Cooper. Well, this is an authorizing committee here so our role is not, of course, to give you the money. That's the Appropriations Committee that does that. But it would be very helpful to us if each of you could perhaps set some of your thoughts to paper on how we might cast in language, direction to the Department to do what it is you think is needed to assist both in the domestic markets and in export markets.

Mr. **Sherwin**. I would like to comment one step further on that. One of the things we would have liked to have seen in the Energy budget or plans, which we did not request—by the way, we asked for a level of funding this year at $16.75 million which again is an absolute minimum number.

I share Mr. Little's opinion, for an industry that has a potential of billions of dollars it's not much of an investment. But what we would like to see, we have some very fine American designs that are almost there, and then the tax credit, you know, just wiped the companies out. I happen to be a major stockholder in one of those companies that is in Chapter 11, primarily because of the loss of quick market opportunity.

What we need there is some funds which we have been told are not possible through current DOE funding, to finish the minor things that will make these machines work day in and day out. We have got the hours on them now. We know the parts of them that work well. We know that we have got the finest air foils, the finest aerodynamics in the business.

We know that we have the best materials work in the business. We know we have the best electrical components work in the business. And we can build a machine that will put 60 kilowatts out at 20 percent of the weight of a Danish design.

Maybe we need to add five percent of the weight to make it hold up. Maybe we need to change the airfoils. We are that close, and then as I point out, our industry being as undercapitalized as it is, the companies could not withstand any aberration in the marketplace and continue doing that R&D, and that is really where we are at.

If I were in a position to write a bill, I would write cost-year contracts or grant or something to these companies which have demonstrated a technical ability to make something work, to get them into the marketplace on some sort of basis that's rational, and we were that close.

When you see, you know, $68 million or $63 million going to a machine—or a company like Boeing who have decided they're not going to be in the business, with that amount of money divided up among the rest of the industry, everybody would still be in business. By the way, we are in favor of finishing the Boeing project. We're so close. You know, it's now in a position to give us some information.

I guess my point is, the way the funds have been allocated, they really haven't gone to the near-term market potential of hardware and we are losing our ability to compete worldwide.

I may point out, the countries that are interested in taking our position are people like Korea, Taiwan, Argentina, India, in addition to the Danes, the Dutch, the British, the Swedes and the West Germans. So, if we don't get moving and capitalize on all this expertise which we have in this country, we are going to lose and we are going to lose significantly and we already have a power plant of the size of Diablo Canyon that's working at a lot less money and about one-third the time.

Senator **Fowler**. Since the competitiveness factor in policy decisions, is the only thing that the administration seems to pay attention to, we need to find a way to flesh that out. We need to specifically recommend ways that we can attract the capital, not from direct government participation, if possible.

We solicit any additional views. We lost the tax credits. It was on the Ways and Means Committee. The reality is, that those aren't going to come back in the next two years.

Mr. **Sherwin**. We are willing to accept that.

Senator **Fowler**. I wish I knew a way to do it, but we have to accept the reality. We have to move on from there and find a way to continue to progress.

Anything else?

Mr. **Sherwin**. I would like to make one minor correction. I am from the Republic of Vermont, not Connecticut.

Senator **Fowler**. Thank you. I will allow that correction.

Thank you very much for coming. We all share the same goals, and your work, comments, and statements will be helpful as we continue to work on these issues.

Mr. **Sherwin**. We will provide you with some language, and also a statement on how we think our industry can be more competitive.

Senator **Fowler**. It will be very helpful.

We will recess these hearings until Thursday at 2:30. Thank you.

[Whereupon, at 4:20 p.m., the hearing recessed, to reconvene Thursday, March 26, 1987.]

RENEWABLE ENERGY TECHNOLOGIES

THURSDAY, MARCH 26, 1987

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:30 p.m., in room SD-366, Dirksen Senate Office Building, Hon. Wyche Fowler, Jr., presiding.

OPENING STATEMENT OF HON. WYCHE FOWLER, JR., A U.S. SENATOR FROM THE STATE OF GEORGIA

Senator FOWLER. Ladies and gentlemen, I want to welcome you to our second subcommittee hearing on renewable energy policy.

Once again we have a distinguished witness list. The staff and I have read the prepared statements. They are uniformly excellent, and they will be made a part of the record of this hearing. I think it is going to be a very fine record.

For purposes of this afternoon, I do want to request each of the witnesses to please summarize their testimony. It will help us proceed directly to the discussion in the hour or so that we have allotted for this afternoon.

The aim of these hearings is to determine how best to influence the DOE renewable energy and energy conservation research and development program. We want to influence the program so that cost-effective technologies become available sooner rather than later.

We heard at our first hearing that the DOE's emphasis on long-range, high-risk research may not be the best approach, given that we want these technology options to be available when they might be needed in the 1990s.

In today's discussion, I'd like to hear how we might redirect DOE's program to advance good cost-effective options.

Do we just need more money? Do we need a different emphasis for the research, more research on manufacturing methods, for example? Do we need more demonstrations? Do we need to pick some technologies that will receive more support than others? If so, how do we pick them? What criteria do we use?

And finally, this is your chance to play Congressman. If you were attempting to write a bill and put your recommendations into effect, what specifically would your legislation include?

If you can help us with these questions, you will be helping us a lot. More importantly you will be helping the prospects for these technologies.

Dr. Blair, I asked you to assume the first position, but since Senator Wirth is here, I think we are going to go back to the original order if you don't mind and invite my colleague, Senator Wirth, to the stand along with Dr. H. M. Hubbard, the Director of the Solar Energy Research Institute in Golden, Colorado.

[The prepared statement of Senator Domenici follows:]

OPENING STATEMENT - SENATOR PETE DOMENICI
MARCH 26, 1987 RENEWABLE HEARING

GOOD AFTERNOON. I'M LOOKING FORWARD TO THE TESTIMONY WE'LL RECEIVE TODAY, WHICH IS THE SECOND AND FINAL DAY OF HEARINGS ON THE STATUS OF OUR RENEWABLE ENERGY TECHNOLOGY PROGRAMS.

I HAVE PREVIOUSLY STATED ON A NUMBER OF OCCASSIONS THAT OUR PRESENT ENERGY COMPLACENCY, COUPLED WITH A FEDERAL DEFICIT CRISIS, NATURALLY LEADS TO CUTBACKS IN A LOT OF IMPORTANT ENERGY RESEARCH AREAS. RENEWABLE ENERGY AND CONSERVATION R&D HAVE CERTAINLY TAKEN A LARGE SHARE OF THE CUTS. BUT IF CONGRESSIONAL ACTIONS OF THE PAST ARE ANY INDICATION, I SUSPECT THAT THIS CONGRESS WILL PREVAIL IN ITS EFFORTS TO PROVIDE ADEQUATE FUNDING FOR RENEWABLE TECHNOLOGY DEVELOPMENT.

THERE SEEMS TO BE A CONSENSUS IN THE TESTIMONY WE HEARD LAST TUESDAY AND WILL HEAR TODAY THAT MARKET FORCES, OIL PRICES, AND INTERNATIONAL TRADE POLICIES HAVE PLAYED A SIGNIFICANT ROLE IN REDUCING THE POTENTIAL FOR RENEWABLES DEVELOPMENT IN THIS COUNTRY. BUT I STILL BELIEVE THAT, WITH THE PROPER EMPHASIS ON CUTTING-EDGE TECHNOLOGIES, WE WILL STILL BE ABLE TO MAINTAIN OUR POSITION AS ONE OF THE LEADING CONTENDERS IN THE WORLD MARKET FOR RENEWABLE TECHNOLOGIES.

STATEMENT OF HON. TIMOTHY E. WIRTH, A U.S. SENATOR FROM THE STATE OF COLORADO

Senator WIRTH. Thank you very much. We appreciate you reorganizing the order and your careful attention to this important issue. You and I also sit together on the Budget Committee where we started work on the Chairman's mark this afternoon, and I will swiftly go over there and represent yours and my collective interest.

Senator FOWLER. You have my proxy.

Senator WIRTH. In the meantime, what I would like to do if I might, Mr. Chairman, is to introduce to you Dr. Harold M. Hubbard, who is Director of the Solar Research Institute in Golden Colorado.

As you remember, Mr. Chairman, at the time that we in the country were taking energy issues seriously in the 1970s, we developed a balanced energy program which had conservation, production, alternative energy resources, and solar energy as major parts of that overall balanced program.

Dr. Hubbard has run the Solar Energy Research Institute in Golden Colorado since 1981 and has done a very distinguished job with dwindling resources. It has been my pleasure to work with him to help in any way possible, and to encourage this valueable contribution to our overall national energy strategy.

I wanted to come over today to not only thank Dr. Hubbard for the great work that he has done, but to introduce him to the Committee. I would like to introduce Dr. Hubbard and his testimony.

Senator FOWLER. I know of Dr. Hubbard, and I know of his fine work. We welcome you here today, and we are delighted to have you come to Washington to participate in these hearings.

STATEMENT OF DR. H. M. HUBBARD, DIRECTOR, SOLAR ENERGY RESEARCH INSTITUTE

Dr. HUBBARD. It is a pleasure to be here, and I appreciate the opportunity. I know that neither you nor Senator Wirth or the members of your committee or your staff need a lecture from me on the energy issues on renewable energy technology, because you are all very familiar with that.

I have in the written testimony attempted to summarize what the current state of technology is and what the program looks like. I would like to give you just a few preliminary comments.

In the first place, energy is a long-term chronic issue. I think in this country we tend to look at it in a very short-term way that makes it either a crises or no problem at all. Neither one of those perspectives is correct. There are immediate needs and there are immediate impacts that need to be considered, but there are no simplistic near term solutions.

We are not energy resource limited in this country. We are technology limited, and we do have to get away from our dependence on oil and gas, and our over preoccupation with it. Generally I think that requires a technology-based energy system that is adaptable to indigenous available resources that is flexible enough to accommodate changeable and specific demands and to accommodate environmental needs, and whose proper exploitation rests primarily on what is our most natural indigenous resource, namely our advantage in science and technology.

Through technological innovation we will and we can provide a diversity of energy options; and having done that we can better control our energy supply, our cost, and we will be able to provide the nation with a secure energy supply. But that is a multi-year, multi-decade effort.

In the crises atmosphere of the late 1970s, which resulted primarily in the implementation of oil replacement programs, a lot of technology was put into place. It was not optimized with respect to cost effectiveness, and it was inefficient. The temporary easing of the market pressures on energy has enabled the renewable program and industry to invest and to plan in a more efficient and more cost-effective way. Properly done, we can take advantage of that time.

It requires multi-year planning. It requires a sustained commitment of our scientific and engineering resources, and that has to be a combination of government and industry. Industry's ability and capability to invest is relatively limited for the time being, so government is going to have to carry a major part of that load.

What will we get out of that? Well, DOE is primarily focusing on domestic energy supply. I think we will improve that without any doubt and we will get some other benefits, too. There will be an impact on international trade. There will be a positive impact on our balance of payments. There will be spinoff applications which lie outside of the energy area. We'll get a considerable amount of good science done, and we will increase our ability to deal with maintaining our environmental quality and our quality of life.

With that statement I would be happy to respond to questions.

[The prepared statement of Dr. Hubbard follows:]

TESTIMONY OF DR. H. M. HUBBARD
DIRECTOR
SOLAR ENERGY RESEARCH INSTITUTE

BEFORE THE
UNITED STATES SENATE
COMMITTEE ON ENERGY AND NATURAL RESOURCES
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

MARCH 26, 1987

I want to thank the Chair and members of the Subcommittee for inviting me to testify concerning the status of renewable energy technologies within the federal program in solar energy R&D. I have chosen to open with a general introductory statement of why I think R&D in renewable energy is important to America. Then I will discuss what the renewable technologies are, their potential to contribute to domestic energy supplies and to world trade, and what research and development the program is doing to enhance the potential of renewables. I will close by touching on SERI's role in renewable R&D.

THE IMPORTANCE OF R&D IN RENEWABLE ENERGY

America runs on energy. Energy is vital to every aspect of American life. Our economy, world-wide strategic position, quality of life, trade balance, and scientific and technical leadership are all intimately tied to energy; they depend upon the U.S. having secure energy supplies, supplies that are reliable, affordable, and that we can control.

Over the decades, America has come to rely increasingly on oil as her major source of energy. But oil is a scarce commodity. It has proven itself vulnerable to disruptions, political instabilities, and price fluctuations. And the future looks even less certain. We will continue to be affected by this vulnerability and the collective actions of those who control the commodity. As domestic supplies diminish, we will depend more heavily upon imported oil. But imported oil is also subject to the same overall constraints as domestic oil. It is not only exhaustible, but as the countries of the world continue to modernize, there will be an ever expanding demand for an ever shrinking supply. Further, our increasing dependence upon foreign oil will become more and more deleterious to our balance of trade.

The reality of this situation does not change radically even with lower oil prices as we have experienced during the last year, though it may appear so. In fact, low-cost oil could exacerbate the situation by causing us to abandon our hard-won conservation ethic, use more energy and import more oil, thereby hastening the end of any perceived oil "surplus." Such a likelihood recently caught the attention of several government officials and oil company executives who are expressing their concerns that America may witness oil shortages and gas lines again in a few years.

Reliance on fossil fuels raises other concerns as well. Energy consumption, by its very nature, can adversely affect the environment, both on a local and global scale. Certain technology advances, such as the use of scrubbers or catalytic converters, can alleviate some of these concerns but they do not eliminate them.

So what must we do? We should continue to expand our energy technologies to include the wide spectrum of available energy sources, tapping our vast technological resources in the process. We will continue to use fossil fuels, of course, for they are very facile sources of energy, and their use and technologies are entrenched in our economy and our way of life. But we must augment our fossil fuels with conservation, nuclear, and renewable technologies.

These sources of energy depend upon indigenous resources. And they require what I like to refer to as "technology-based energy systems." I define such systems as adaptable to available resources and specific needs and whose proper exploitation rests primarily upon our ingenuity, science, and technology. Systems that rely upon our own resources and our own technology are not easily subject to disruption. Through technological innovations which provide a diversity of energy options, we will eventually be able to better control energy supply and cost and ensure that our nation is provided stable and adequate energy supplies.

The renewable energy technologies are an especially important ingredient in this energy mix—their potential is large. Our use of renewable energy is not limited by the resource; it is limited only by current technology. We are in the process of developing these technologies; that's what the DOE's renewable R&D program is all about, and that's what the Solar Energy Research Institute is all about. But to get the technologies to maturity and to merge them into the nation's energy infrastructure, to make renewable energy a major contributor to our energy supply, takes perseverance, time, dedication, talent, and money.

The average energy technology application takes decades to develop and decades more to fully integrate into the nation's infrastructure. Diesel power, for example, took 60 years of development before it was introduced to commercial applications, and another 30 to 50 years before it enjoyed widespread commercial success. We have had similar experiences with many of the other energy technologies, from hydropower to nuclear power. In this respect, we cannot expect the development period for the renewable technologies to differ significantly.

To fully integrate renewable energies into our infrastructure, we need a multiyear research and development program with stability and continuity. Among other things, this means we must avoid a crisis atmosphere and its concomitant crash program mentality. Long-range stability and continuity, resulting in an ordered, cost-effective program, offers the best means for our renewable technologies to advance and will allow us to push the correct technologies, explore the promising avenues, set clear goals, and manage the program with efficiency and with clear objectives.

A stable and continuous effort allows us to more systematically and effectively bring the best technologies to the point where industry will be able to adapt them and commercialize them on a larger scale. Once they gain widespread acceptance, the industries themselves will be able to assume an increasingly greater share of the responsibility to refine the technologies. Industry can accomplish this most efficiently if we are not in a "crisis" situation; hence, we need to continue the development of these technologies now, rather than later when the need becomes urgent and the cost becomes high.

Even though many of the renewable technologies are quite young, several are already beginning to find commercial applications. Wind electric conversion systems, for example, are gaining a market foothold and photovoltaic systems are vying with diesel generation for use in remote areas in this country and around the world. These applications, and more, have arisen partly because of the progress the DOE program has made on materials and better designs, thus improving system efficiency, cost, durability, and reliability. In the last ten years the cost of photovoltaic systems was reduced from greater than $600 per watt to less than $5 per watt, while their life expectancies increased from less than five years to nearly twenty years and their efficiencies improved dramatically. This story has been repeated in several of the technologies, with much of the credit due to advances resulting from the national program.

Bringing the renewable technologies to the point where they will significantly penetrate the U.S. markets will not only help give us a stable, secure energy resource that we can control, it will help our economy by providing an opposing force to rapid increases in prices of imported petroleum. The decades required to make renewables domestically competitive roughly coincides with present expectations for the timing of strong upward pressure on international petroleum prices (although an earlier market disruption could occur).

Meanwhile, many of these technologies are becoming competitive in special situations and niche markets, such as providing energy in remote areas. This has given rise to a fledgling industry base, a base that is important to renewable energy and to the nation. It provides the starting point for the ordered evolution of these technologies into positions as major contributors to the domestic energy supply. We are doing what we can to support the needs of industry by providing technical information and design assistance.

One area of assistance pertains to potential foreign markets for remote applications. In the Third World, according to a study done by Frost and Sullivan, there are an estimated two million unelectrified villages remote from power supply grids. This can be an important market during the transition decades ahead. In fact, U.S. suppliers are already starting to penetrate these international markets. They are being helped in this endeavor by CORECT, a joint DOE, Commerce, and State Department initiative that is identifying markets and financing mechanisms and agencies, removing some trade barriers, educating U.S. industries and possible customers, and bringing together interested parties.

As government and industry continue R&D, we eventually will be able to bring the renewable technologies to the point where they will significantly penetrate both U.S. and international markets. Not only will this result in a major improvement in our domestic energy supply, it should help our economy, our global competitiveness, and relieve some of the pressures on our environment.

STATUS AND DIRECTION OF RENEWABLE ENERGY RESEARCH AND DEVELOPMENT

Current use of renewable energies is based mostly on two mature technologies: hydroelectric power and the burning of wood and waste products, such as municipal solid waste and the wood-chip waste produced and consumed by the lumber industry. These technologies provide nearly 9%, or about 7 quads of our domestic energy supply. (A quad is one quadrillion BTUs, which is equivalent to 170 million barrels of oil.) Based primarily on a broader application of these two mature technologies, the National Energy Policy Plan (NEPP) projects that by the year 2010, energy consumption from renewables will represent from 13% to 15% of our domestic energy supply, or approximately 15 quads.

The NEPP recognizes, however, that renewable energy consumption could be much greater than this if all of the renewable technologies are brought to maturation and can penetrate the market at a timely rate. In fact, the energy contribution potential of renewables, defined as the maximum amount of energy that could be economically extracted from the renewable energy resource base, has been estimated to be as high as 80 quads once the technologies are fully developed; 80 quads is approximately equal to the current total energy consumption by the United States today.

To hasten the technologies toward this potential we must take advantage of one of America's greatest assets, its intellectual capital. As much as, and perhaps more than any other energy technology, the development of the renewable energies embraces sophisticated science and high technology: thermodynamics, solid-state physics, genetics, microbiology, physical chemistry, biology, biophysics, biochemistry, quantum physics, and more. These disciplines are applied across eight major technology areas that constitute the DOE Renewable Program: wind energy, photovoltaics, solar thermal energy, biofuels, solar buildings, ocean energy, hydroelectric power, and geothermal energy. The research and development under the DOE solar program concerns itself primarily with the first six of these technologies and with two areas that support these technologies: resource assessment and technology transfer.

The technologies that the program supports are diverse in nature and are in varying stages of maturation. Their applications are broad and they will be entering the nation's energy markets at various times over the next few decades. We can make some general statements regarding them, however. In all of the emerging technologies great strides have been made during the past decade. For example, the cost of energy derived from most of these technologies has decreased by an order of magnitude or more. At the same time, the energy systems fostered by the technologies have become increasingly reliable, more efficient, and longer lived. These advances have resulted in emerging markets for most of the technologies. Where ten years ago there were virtually no extant markets in the emerging renewable technologies, today, even though the renewable industries are fledgling, the market is substantial, especially for distributive uses and stand-alone applications.

These markets have grown primarily because of the scientific and technological advances we have made in the renewable energies. Compared to where we were ten years ago, our theoretical understanding of the basic conversion phenomena, the solar resource and the pertinent materials sciences required is much advanced. Our scientific and technical data base is more extensive, and we have a better understanding of the factors limiting the technologies. But, this does not mean that we have come all the way down the road. In many instances we have just begun to scratch the surface. We have solved some problems and have overcome some basic limitations. Much of our progress is impressive, but has followed the path that most new uses of technical development follow. In the first few years, one discovers the proper questions to ask, starts to define the sciences to be studied, chooses the technology options that should be followed, and identifies the principle barriers to be overcome. This we have done fairly well. But if we are to help our nation satisfy its future energy needs, and help our industries gain stronger footholds in the larger markets that will be available, we must vigorously pursue development of the technologies, maintaining our momentum in advancing the solar sciences and enhancing our knowledge of the resource.

In wind, for example, we must improve our understanding of the basic physical phenomena created by the wind turbine's interaction with the environment. This entails further research on fluid dynamics, aerodynamics and structural dynamics. We must also continue to design and test new air foils and controls and to assess and collect data on wind and wind patterns.

In photovoltaics, we must continue our efforts to design and fabricate photovoltaic devices that are more efficient, less expensive, more reliable, and easier to make. This entails increasing our knowledge of the quantum, solid-state, and statistical nature of photovoltaic phenomena. It also requires major efforts in material sciences, to discover new materials and to enhance known materials; in growth mechanics, to better understand the reactions that occur during fabrication of solid-state devices; in resource assessment, to understand the nature of light and of solid-state device reactions to various portions of the spectrum under varying conditions; and in device engineering, to develop the best configurations and designs for photovoltaic devices.

For solar thermal technology, we must further research materials and optics, to find materials for solar collectors that are durable, highly reflective, light, and inexpensive. We also need to continue our investigations on fluids and storage materials, to find the best mediums for receiving, storing, and transporting energy. We need to continue work on structural dynamics, to determine the best structures for supporting solar collectors; and on control systems, to automatically control the collectors and systems in order to maximize the collection and use of the solar flux. We also need to gain a more thorough understanding of photochemical and thermochemical effects for the production of fuels.

For biofuels, there is a great deal of work to be done in genetic engineering, chemical, biological and thermodynamic sciences. To produce liquid and gaseous fuels from wood, herbaceous crops, and agricultural and municipal wastes, for example, we need to develop enzymes, microbes and bacteria which optimize energy products from these feedstocks. We must also develop better methods of fermentation, genetically engineer new organism strains, discover new and better ways to cultivate energy crops, enhance anaerobic digestion, and design reactor systems for gasification.

In solar buildings research we are continuing to investigate phase-change and state-change materials that could eventually be used in building materials, such as particle board, for storage of heat to aid in space heating. We must also improve electrochromic and vacuum window concepts for space heating and cooling, and study new desiccant materials for space cooling. And, we must develop better building designs to allow greater use of natural lighting to help save the vast amounts of energy that lighting can consume.

Ocean thermal energy conversion systems require extensive experimental testing. In addition, we need to perform further thermodynamic, materials, and structural research, especially on cold-water pipes and heat exchangers.

In support of these technologies, we must also extend our assessment of all the renewable energy resources. To do this, we have to increase and improve our data collection, our data bases, and our resource models. Further, we must continue to transfer our technology to the private sector: through subcontracts, cooperative research arrangements with industry and academia, and through all the available information media.

THE RENEWABLE TECHNOLOGIES, THEIR STATUS AND FUTURE

Having given you a summary of the R&D program and where the technologies stand, I will now present the technologies in more detail, discussing what they are, their status, and what the program intends for their future research.

Wind Energy. Winds are created by the sun's unequal heating of the earth's surface and atmosphere and by the regional differences in pressures that result. Major wind patterns are global and regional. But complex local patterns also develop, influenced by local terrain and by natural and man-made obstacles. Thus, wind turbine technology involves very complex aerodynamic phenomena.

This nation's program on wind energy deals with changing the form of the wind into electric energy. Parts of this technology are maturing, but Wind Energy Conversion Systems (WECS) still have many outstanding research issues, for WECS have turned out to be a challenge to the research and design engineer.

When the wind flows through the area swept by the rotor blades (or airfoils) it sets in motion certain physical processes. For steady-wind conditions—when the wind is moving at a constant speed and direction—the rotor airfoil shape is designed to create lower pressure on the top of the blade and higher pressure on the bottom. The net difference in the pressure generates aerodynamic lift, causing the rotor to turn. The rotating blades drive the gearbox and generator which, in turn, produces electricity.

There are two basic approaches for converting wind to useful energy: vertical-axis wind turbines, in which the axis of the rotor's rotation is perpendicular to the wind stream and the ground; and horizontal-axis machines, whose axis of rotation is parallel to the wind stream and the ground. Both types contain five basic subsystems: (1) a blade or rotor, which is the energy conversion device; (2) a drive train, usually including a gearbox and generator; (3) a tower that supports the rotor; (4) various turbine supporting systems, including controls and electrical cables; and (5) "balance-of-station" subsystems, such as ground support equipment and interconnection equipment.

There are many configurations possible for each type of machine. For example, machines can employ different yawing mechanisms (to keep the machines oriented properly in the wind stream), or different numbers of blades, or differently pitched blades, or blades that are located upwind or downwind of the tower. Plus, machines can range in size, producing just a few kilowatts to more than four megawatts of electricity.

Since the mid-1970s this country has made large strides in wind technology. Improvements in the cost, performance, and lifetime of wind machines have reduced the cost of wind-generated electricity more than tenfold, from more than $1.50 per kilowatt-hour to between 10¢ and 15¢ per kilowatt-hour. The reduction in cost and the improved reliability are big reasons for the dramatic rise in wind-generated electricity in the United States over the last few years. Although wind energy conversion systems are eminently useful for dispersed applications, the United States employs them mostly in wind farms. There, they are used as supplemental power for utilities. California is the pioneer in this field. The state has more than 1300 megawatts of installed capacity and produced more than 700 gigawatt-hours (i.e., 700 billion watt-hours) of electricity in 1985.

The improvements in cost, performance, and lifetime of wind machines are related to advances the program has made in the technology. We have, for example, improved our understanding of wind shear—the variation in wind speed with height above ground. And, by operating and testing experimental and commercial wind machines, we understand better the vibrational characteristics of wind turbines and the loads induced by gravity, centrifugal forces, and average wind conditions. We have also improved components and subsystems such as (1) advanced teetered rotors, which reduce the loads induced by wind sheer; (2) flexible towers and drive trains, which weigh and cost less; (3) improved gearboxes; and (4) improved fabrication techniques for steel, wood, and fiberglass blades.

Researchers have developed a new family of wind turbine airfoils that satisfy the unique requirements of fixed-pitch, horizontal-axis wind turbines. These designs avoid the undesirable performance characteristics of aircraft airfoils in wind turbine use. And, in resource assessment we are studying the micro-environment—the effects that natural and man-made objects have on local wind patterns.

The program has also investigated the environmental effects of wind turbine operation, particularly noise and radio/television interference. This research has provided the basis for industry-consensus noise measurement techniques currently being developed by the American Wind Energy Association.

Although the results of wind research have been successfully applied in such places as the California wind farms, American wind machine manufacturers are facing a stiff challenge in the domestic market from European manufacturers. We need to continue our research to make wind machines more reliable, more efficient, and longer lived, and to reduce the cost of wind-generated electricity to 4¢ per kilowatt-hour.

To achieve this, the program is doing research in two parallel areas: the basic science of wind turbine dynamics, and advanced components and systems research. The science of wind turbine dynamics includes research in (1) atmospheric fluid dynamics, addressing complex wind patterns and turbulence; (2) aerodynamics, concerned with the interaction between atmospheric flow and the turbine's rotor; and (3) structural dynamics, concerned with the loads or stresses on the components of a wind system. These activities will improve our understanding of the basic physical phenomena created by the wind turbine's interaction with its environment.

Advanced components and systems research includes (1) advanced concepts, such as advanced air foils, controls, and drive trains; (2) supporting research, which includes technology assessment, electrical systems analysis, environmental impact research, and wind data collection and verification; and (3) the testing and analysis of DOE and industry machines.

Photovoltaics. The basic power element of a photovoltaic (PV) system is the solar cell. Typical solar cells are made of crystalline silicon, the material of the semiconductor revolution. Today, a typical cell for power applications can have an area of about 100 square centimeters constructed from a thin (less than 0.5 millimeter in thickness) silicon wafer. The photovoltaic effect in silicon and other materials arises from the internal electronic structure and the electric fields that can be introduced. One way to introduce electric fields is to use two or more thin layers of two different semiconductor materials. Another way is to introduce different dopant atoms (atoms that have one more or one less valence electron than the host material) into two different thin layers of a structure using the same semiconductor material. A junction formed between two of these layers creates an internal voltage. Sunlight striking the solar cell liberates electrical charge carriers within the cell. The electric charges are separated by the internal electric field to produce an electric current. Metal contact lines on the top and bottom surfaces of the cell enable the current to flow through an external circuit to produce electric power. Electric power is the product of voltage and current—electricity directly from sunlight is the result.

A typical crystalline silicon cell (100 cm^2) produces a little more than one watt of power. More power is produced by interconnecting several solar cells and encapsulating them in a single package—the photovoltaic module. Modules, in turn, may be grouped together and interconnected to form arrays. The direct current (dc) generated by the photovoltaic array can be used as is or passed to a power conditioning subsystem (PCS) that converts the dc electricity to the more commonly used alternating current (ac).

Before the inception of the National Photovoltaics Program, whose intent is to make photovoltaics feasible for terrestrial uses, photovoltaic systems were used almost exclusively to power satellites. Now, eleven years after the start of the program, the United States has installed thousands of photovoltaic systems around the world. They include large systems, like a 6.5 megawatt installation in California; small systems that pump water in Nigeria or light a cabin in the Montana mountains; and intermediate-size systems, like Alabama Power's 100 kilowatt amorphous silicon installation.

Largely because of the progress made in the national program in the last eleven years, the cost of photovoltaically generated electricity has dropped from more than $5 per kilowatt-hour to less than 50¢ per kilowatt-hour. In the same span, the lifetime of photovoltaic modules has gone from less than five years to the point where most companies now offer ten-year warranties for their modules. Recent progress in the program portends that the new generation of crystalline silicon modules will last more than 20 years.

Program researchers have devised new methods to inexpensively purify silicon. They have also discovered new semiconductor materials and have devised new material combinations for use in photovoltaic devices. For example, they have successfully fabricated the first solar cell to be made from gallium-indium-phosphide, one of the best materials to use in tandem with gallium arsenide cells for producing high-efficiency multijunction PV devices.

The program has also joined in many cooperative projects with industry and academia to form research teams, develop materials, and explore concepts. One of these, a project involving Boeing and SERI, led to the development of thin-film cells of copper-indium-diselenide in combination with cadmium-zinc-sulfide. The cell achieved a 10.3% conversion efficiency, at that time the highest of any non-single crystal thin-film cell measured by the program.

Another way the program has been crucial to the success of photovoltaics is by providing sophisticated measurement, testing, and analysis support to the photovoltaic community.

But to make photovoltaics widely accepted, the program must maintain the momentum of its research, bring the cost of photovoltaically generated electricity down to 6¢ per kilowatt-hour, and penetrate the utility market. To reach this goal, the program is working with industry to increase conversion efficiencies, decrease cost, increase reliabilities and lifetimes, explore new alloys, investigate new fabrication techniques, and study new materials, device structures, and concepts. Under program guidance, flat-plate modules made of crystalline silicon are reaching beyond 15% efficiency. And some production cells are starting to reach efficiencies of 18% to 20%. But more than that, some experimental cells have gone beyond 22% efficiency under normal sunlight and have approached 28% efficiency under concentrated sunlight. These efficiencies are greater than thought possible just a few years ago.

Many other materials are also being explored. For example, the program, through the Amorphous Silicon Research Project, has formed some of its most successful partnerships with industry and academia to explore thin-film materials like amorphous silicon, the material that the Japanese have exploited to capture the market for powering consumer items like radios and calculators. These partnerships have resulted in substantial progress that will help open new markets for thin-film photovoltaics. However, if amorphous silicon devices are to enter the large power markets and if the United States is to adequately address the challenge from the Japanese, we must overcome technical barriers that currently limit amorphous silicon devices.

Research is being done on other thin-film materials and multijunction concepts using these materials, concepts that could give device efficiencies as high as 24%. Amorphous silicon laboratory cells have been made with 11% efficiency. Over the next several years, the program will conduct research to raise efficiencies up to 18% for small cells and 12% for large-area submodules. Another concept being explored intensely is the use of single-crystal gallium arsenide and its alloys in multijunction configurations. With this approach cell efficiencies as high as 35% to 40% could eventually be achieved. This is a relatively new concept, and the best laboratory device made to date is around 26.5%-efficient. The program intends to bring this up to greater than 30% in the next few years. These goals are ambitious and it is not yet clear what approaches will be winners, but the pay off is high.

Solar Thermal. Solar thermal systems use tracking mirrors or lenses to focus sunlight on thermal receivers. The receivers absorb the solar energy as heat, which is used to produce electricity, process heat, or to carry out chemical reactions. The program is currently investigating two types of solar thermal systems: central receivers and dish systems. The central receiver system, primarily used for central utilities, has been proven at a 10-megawatt installation near Barstow, California. A typical dish achieves temperatures up to 2700°F and generates about 50 kilowatts. A dish system installed at Shenandoah, Georgia, produces 400 kilowatts of electric power for air conditioning and other uses at a nearby textile mill. An example of an ambitious and successful trough installation is a privately funded, 45-megawatt, parabolic-trough electrical system in southern California—a system that may be expanded to several hundred megawatts in the near future.

Concentrated solar flux in the form of combined photothermal effect can be used for applications other than heat and electricity. For example, evidence for enhanced chemical bonds dissociation has been obtained in laboratory research which could lead to solar detoxification of hazardous chemical waste.

The research performed under the solar thermal program has resulted in significant technology innovations. Program researchers have developed a thin, stretched membrane structure to replace heavy glass reflectors. They have also developed a direct-contact heat exchanger, which should enhance receiver efficiency and reduce cost. Also, working with industry, the program developed a polymer-based reflector material with low cost, long life, and high reflectivity. The 3M Corporation is now marketing the product as ECP-300 Solar Reflecting Film for a variety of industrial applications.

These kinds of advances have enabled solar thermal systems to produce electricity at 13¢ per kilowatt-hour, as cheaply as any renewable technology. These costs are presently quite competitive for distributive applications. But the program's long-range intention is to make solar thermal competitive in larger, more centralized markets. This entails bringing the costs down to 4¢ per kilowatt-hour. Continuing research in collection technology, energy conversion technology, and systems technology for each of the three types of systems is needed.

Biofuels. Biofuels—energy from wood, herbaceous crops (non-woody vegetation, such as grass), or agricultural and municipal wastes—is potentially the largest and most diverse renewable energy resource.

We are all familiar with direct combustion, which constitutes the largest use of biofuels today. Many people burn wood to heat their homes, municipalities burn solid waste for co-generation, and lumber companies burn wood chips for heat or co-generation. This use is well established and mature, although there are several avenues of research that could make such burning more efficient. Research in the national program does not emphasize this utilization of biofuels. Rather, it emphasizes research on producing liquid and gaseous fuels from biomass. Success in making these kinds of fuels is extremely important because they would supplement our use of liquid and gaseous energy in transportation, a sector that constitutes more than 40% of our national consumption. Liquid fuels include alcohol fuels, diesel and gasoline derived from waste (biocrude), and diesel and gasoline derived from microalgae and plant oils. Gaseous fuels include biogas and synthetic gas (syngas).

We can make alcohol fuels from trees, grasses, and common agricultural crops such as corn and other grains. In fact, alcohol fuels from grain are presently being used commercially. More than four billion gallons of ethanol-gasoline blends are already being produced from crops each year for use as transportation fuel. With minor modifications, automobile engines can be built to run solely on ethanol. Brazil already has two million cars fueled by pure-alcohol. Under the DOE-sponsored program, engineers developed a methanol fuel system for cars that catalytically dissociates liquid methanol into hydrogen and carbon monoxide. These gases are then burned at high efficiency in a modified piston engine. The process produces a high thermal conversion efficiency with reduced emission of exhaust pollutants.

Agricultural crops have the required fermentable sugars to produce alcohol fuels, but are expensive to use. So, to reduce the cost of alcohol fuels to less than $1 a gallon within the next fifteen years, and to assure abundant supplies, researchers are looking at biomass forms such as trees and grasses. To produce alcohol fuels from these biomass forms, they are investigating two basic avenues: how to grow crops and grasses that have a good yield and a high cellulose content (are easily fermentable to alcohol), and how to improve the fermentation. To improve fermentation, they are using biological engineering to create enzymes ideal for converting cellulose into smaller sugar units. They are also studying acid processes that will accomplish the same thing.

Another important improvement sought in alcohol fuels is an efficient method to change xylose, the major hemicellulose sugar in hardwoods, into xylulose, a fermentable sugar. The program is currently sponsoring advanced genetic engineering to develop new microbes capable of fermenting xylose. With a good procedure for xylose fermentation we may be able to produce ethanol at $0.80 per gallon by the year 2010.

The ideal substitute for petroleum-based gasoline and diesel fuels would be gasoline and diesel derived from a renewable resource. The program is investigating several techniques for thermally transforming a variety of feedstocks such as wood, energy crops (plants, grown under intensive culture conditions, for their fuel value), and municipal wastes into a biocrude liquid that is similar to residual oil. The heat used induces the necessary chemical changes in the raw feedstocks. The biocrude liquid produced in this fashion is refined to remove excess chemically bound oxygen in order to produce gasoline and diesel fuels.

Two of the methods researchers are developing to produce biocrude from raw feedstocks are fast pyrolysis and catalytic, high-pressure pyrolysis. They are also investigating two approaches to refine the biocrude into gasoline and diesel fuel: (1) using catalysts to add hydrogen and remove oxygen from liquid biocrude products, making them more like crude oil; and (2) using special catalysts at moderate temperatures to transform vaporized biocrude products into gasoline or diesel fuels in processes similar to commercial refining operations.

Program researchers are also exploring ways to produce diesel and gasoline from microalgae and oil seeds, like sunflower seeds. Program scientists are culturing and evaluating thousands of strains of microalgae in an effort to identify about 20 of the most prolific oil producers. Thus far, they have developed strains that produce up to 66% of their body weight as oil. Scientists are also studying the biochemical mechanisms that control the oil-producing process. Once they know these, they will be able to genetically engineer algae with the desired properties. And once researchers determine the best environment in which to cultivate the algae, they will be able to design and build systems to produce the oil, with a particular emphasis on using the saline waters of the southwest.

For oilseed crops, genetic engineers are developing new plant strains, with emphasis on the winter rapeseed plant, that will produce seeds that are more than 40% oil by weight and that will have high seed yields. The oils derived from these seeds contain more chemically bound oxygen and are much thicker than crude oil. Consequently, they cannot be refined by conventional techniques. Thus, program researchers are working on two promising technologies for refining plant oils, transesterification and a novel approach to catalytic cracking.

The United States is also studying the use of anaerobic digestion to produce biogas, medium-Btu and high-Btu methane gas from animal, plant, wood, and municipal waste. Anaerobic digestion is the degradation of organic matter by bacteria, in the absence of oxygen, to produce biogas. The digestion takes place in three steps. First, bacteria break down cellulose and other complex biological molecules into simple sugars. Then, other types of bacteria digest these products, producing organic acids. Finally, specialized bacteria, called methogenic bacteria, degrade these organic acids to methane and carbon dioxide.

Currently, anaerobic digestion is being used for manures, but the process is not optimized. To make the process more efficient and adaptable for other feedstocks, however, researchers are developing different strains of bacteria to promote anaerobic digestion, engineering better strains of herbaceous crops, and developing reactor systems.

Thermal gasification is a well-known technology for converting plant or waste material into synthetic gas (syngas). And today, there are many commercial uses for syngas. But these gasifier systems produce only low-Btu gas that contains too much nitrogen. Program researchers are developing ways to produce high-quality, medium- and high-Btu synthetic gas. To achieve this, they are designing reactors and new gasification concepts. One interesting concept involves using a catalyst to thermally degrade plant materials. This concept has a potential for methane yields as high as 11 cubic feet per pound of biomass. Although in the early stages of research, this concept looks promising.

One successful gasifier design is a high-pressure oxygen gasifier based on principles derived from downdraft gasifiers used during World War II to power vehicles. In this design, over 99.95% of the tars and oils in wood or agricultural waste feedstocks are converted to synthetic gas by passing through a heated charcoal bed, with injection of supplemental oxygen. The gases in turn can be converted to methanol or ammonia for fuel use. The project received an IR-100 Award, and has been taken over by private industry for scale up and commercialization.

There are many advantages to bringing syngas technology to the point where the private sector can commercialize it. It will help communities to dispose of solid wastes; it will generate a market for energy crops and fuel wood; and it will provide large amounts of gas in regions of the country where domestic natural gas is in short supply.

Buildings Research (Active and Passive Heating and Cooling). Perhaps the oldest way of using the sun for energy is to use it directly for heat. Even the most ancient civilizations took advantage of this. Of course, we are quite a bit more sophisticated in our approach today. In this technology, we try to help the natural processes along through materials research, lighting research and through innovative designs that will help us heat or cool our buildings.

In materials research, one innovative concept is phase-change materials. These materials change their state from solid to liquid as they absorb heat during the day, and then by reversing phase change, release their stored heat at night when it is cooler. This has an obvious function for space heating. Researchers are improving the phase change idea by making materials that change from one solid state to another at room temperature, (solid-to-solid) absorbing and releasing thermal energy as they do so. With more development, these materials could be incorporated into common building materials, such as particle board and gypsum wallboard, to produce lightweight building components with high thermal storage capacities.

Two new concepts the program has devised for space heating and cooling are the electrochromic window and the vacuum window. These are existing candidates for development and eventual commercialization. Electrochromic windows have a thin coating whose optical transmission can be changed by electrical means, thus controlling the amount of solar energy passing through the window. Vacuum windows, funded by the Conservation Program, use a high vacuum space between two glazings with low-emittance coatings to achieve an insulating value nearly equivalent to that of a solid wall. The two glazings are separated by small glass beads that counteract the atmospheric pressure, and the glazing edges are sealed by laser welding performed in a vacuum chamber. These two concepts need further work before they can be commercialized, especially the optical switching layer for the electrochromic window and the sealing process for the vacuum window.

Researchers are also investigating other ways to cool and heat houses using solar energy. Studies include desiccant materials and more efficient solar systems for water and space heating. Systems that incorporate desiccant materials, such as lithium chloride and silica gel, absorb water out of the air and exhaust the water outside the building—especially useful for space cooling in humid, tropical climates. But such desiccant materials are just some of the many possibilities in this field. There are, for example, several new organic materials with high moisture absorptivity that look promising as desiccant materials for solar cooling.

For water and space heating, researchers are investigating more efficient heat pumps and flat-plate solar collectors. Both of these concepts are currently enjoying some commercial success.

Researchers are also investigating the design of buildings to take maximum advantage of natural daylight designing techniques to convey daylight into the interior of buildings. These efforts in lighting research will help save large amounts of energy in office buildings as well as in homes.

Lastly, work is centering on the development of analytical methods to predict the performance of systems using advanced components and solar design, and the monitoring and evolution of performance of solar building technology. The program plans to continue to monitor, analyze and evaluate the performance of advanced solar building technologies and to further develop analytical tools to allow architects, engineers, and homebuilders to predict the performance of advanced systems.

The program feels that continued commitment to research in solar buildings is important, not only because of the large potential energy savings and the potential for commercialization, but because of international competition especially from Sweden and Japan.

Ocean Thermal Energy Conversion (OTEC). This technology uses the temperature difference between the surface of the ocean and its deeper waters to generate useful energy. It will be most applicable for tropical islands and for areas along the shores of the Gulf of Mexico. Islands are favorable because they usually have to import their conventional energy supplies, a very expensive method. They are also favorable because, besides energy, OTEC systems can be used to produce fresh water and food products. The primary OTEC options are open-cycle systems and closed-cycle systems. The DOE program emphasizes open-cycle systems.

In an open-cycle system, seawater is the working fluid. Warm seawater is introduced into a vacuum chamber where it produces low-density steam to drive a turbine. The steam then passes through two condensers. The first, a surface condenser, can produce fresh water by desalination of the sea water. The fresh, condensed water is removed while the rest of the steam is passed through a direct-contact condenser and discharged to the sea.

The DOE program pioneered the development of the open-cycle system. One especially significant innovation program researchers developed in this area is an efficient device for evaporating the warm sea water, known as the vertical spout evaporator. Warm sea water is pumped upward through a vertical pipe and exits in a manner similar to a water fountain, with evaporation taking place around the outside of the pipe. The evaporator design results in minimal pressure and vapor losses, as well as less required flow and hydraulic pumping power, compared to other designs. The vertical spout evaporator won an IR-100 Award, and is the subject of a U.S. patent.

Program researchers also developed a direct-contact condenser that can condense 98% of the turbine exhaust steam, along with a device for passive removal of noncondensable gases at the sea-water intake.

America's only extant system is a small, experimental one being built in Hawaii. This system is helping us to define the critical issues we need to explore in the long term. One such issue concerns how to make cold-water pipes more durable and flexible. Cold water pipes that bring the cold water up from the depths of the ocean to the OTEC plant are also potentially important for improved aquaculture processes, because the cold water is high in nutrients and a good culture medium.

Future program research will emphasize experimental verification and testing, thermodynamic research and analysis, and material and structural research. The objective of the experimental verification and testing program is to qualify functional feasibility, performance, and operational characteristics of OTEC components, such as heat exchangers and process controls, on a scale that can be extrapolated by industry in designing small plants. The program will conduct a set of heat and mass transfer experiments on OTEC components. This will lead to tests at the 165-kilowatt level.

One objective of the thermodynamic research and analysis program is to experimentally determine the effects of trapped gas bubbles and actual seawater on the open-cycle conversion process. The program will also experimentally validate selected analytical power system models at a scale sufficient to extrapolate the data beyond the laboratory level. Confidence in these models is important if industry is to design open and hybrid cycle power systems that meet the long-range cost goals of the program ($3200 per installed kilowatt). Achieving these goals depends upon increasing the output of the power system and reducing the projected life-cycle costs of major components.

With its materials and structural research, the program will design and test new materials and concepts for heat exchangers and cold water pipes. For cold water pipes, for example, it is important to design pipes that not only are strong and resistant to corrosion but also are flexible and easily deployed.

Resource Assessment. Resource assessment supports the technologies by providing information on the nature and extent of the available solar resource. This information is vital to properly develop, design, site, select, and operate various solar energy conversion devices or systems. The existing data bases, models and assessments are either limited, incomplete or insufficiently accurate for good system analysis in localized regions. The program is working with NASA and NOAA to enhance the data base to the extent possible. It is also creating increasingly sophisticated computer models that simulate various aspects of the solar resource, helping us to augment our data, analyze it, and understand it better. Using these models it is possible to simulate the resource in areas of the country where ample data is not otherwise available. One model, for example, simulates the solar spectra and the spectral contents under specified conditions. The spectra simulated by this model is being adopted as an international standard.

In many situations, though, we do not have the collection facilities to give us the proper data base, and we do not have the models that can simulate the resource under given conditions. Although this is gradually changing with more data collection, the growth of data bases, and the development of models, the program intends to strengthen and expand this effort. This will help us provide the nation with the necessary information on its renewable resources.

Technology and Information Transfer. Information is transferred from the DOE solar program to industry, academia, and others in the private sector in several ways. One of the most direct and effective methods is through the partnerships the program has formed with industry and academia. In developing the technologies, the DOE program has worked closely with industry and universities. In this way, research results are directly available to the wider community.

A direct avenue for transferring the information is through subcontracts. In some research areas, for example, the program subcontracts as much as 50% of the research to private industry and academia.

The DOE's Solar Technical Information Program gathers research results, packages them in written and visual information products such as pamphlets, books, and video tapes, and disseminates them to a broad audience through outlets such as the Superintendent of Documents, National Technical Information Service (NTIS), and cooperative agreements with private publishing firms. This effort spreads the information to a large public and private sector audience that includes industry, professional associations, researchers, entrepreneurs, and state, local, and federal agencies.

Hydroelectric. Hydroelectric power is well known and has been a fact of American life for many years. It is one of our most mature and proven technologies. The fact is, there are very few research and development problems left to resolve; and what there is, is left to industry.

Geothermal. Geothermal technology converts heat stored in geological formations into useful energy. Present technology uses geothermal steam that appears at fissures or places near the surface to produce electricity.

Researchers are also investigating magma, hot dry rock, geopressured and hydrothermal resources. In all of these areas researchers are studying ways in which they can improve the heat transfer between the resource and the working fluid, and defeat the corrosion that occurs due to geothermal brines.

THE ROLE OF THE SOLAR ENERGY RESEARCH INSTITUTE

The accomplishments and future research plans of the program speak not only to our past successes but to our present and future need to maintain and build our momentum in scientific research and technological innovation. Accomplishments to date, though impressive in themselves, only lead the way to the next step in a series that should help renewable technologies achieve their goals and enter America's energy mainstream. To get there we need to continue our commitment to renewable energy research. But we must do so not in a haphazard way, a way that follows a "crises mentality" where funding will skyrocket one year and dive the next. We must, rather, have a steady and rational commitment that looks years ahead, a commitment that engenders consistent progress in the technologies, allowing us to optimize and introduce them into the infrastructure in a smooth and timely manner.

A steady and rational commitment also allows the nation to build and maintain a recognized research center devoted to understanding and utilizing our solar energy resource. Such is the Solar Energy Research Institute. Behind the commitment of the nation, the Solar Energy Research Institute has been intimately involved with the effort in renewable energy research; managing a spectrum of research programs; subcontracting research to industry, universities, and other institutions; performing research; and maintaining world-class measurement facilities. And recently, with the consolidation of the solar R&D program, SERI has become the primary center for the DOE program in the solar energy technologies. SERI's research responsibilities are complemented by those of Sandia National Laboratories, in systems development, and by centers of excellence in other national laboratories.

SERI-supported research was directly or indirectly involved in many of the accomplishments mentioned above in the descriptions on the renewable technologies. But these accomplishments are only the most visible evidence of what a research center like SERI is about. SERI's value goes well beyond these visible benchmarks, to rest in the significance of our day-to-day research, and in our continual building of important scientific and technological data bases for use by industry. It resides in the scientific expertise of our staff and the passing of that expertise, through the staff's relationships with industry and academia, to the wider technological and industrial communities. It lies with our discoveries, innovations, and patents, and with our intimate involvement with the scientific and technical community, through the national and international conferences we attend, and through the professional journals and periodicals in which we publish. And it lies in the development of sophisticated laboratories, which are available for cooperative use by the solar research community.

SERI came into being as a result of the 1974 Public Law 93-473, which established the Solar Energy Research Institute to enhance the contribution of solar energy to our national energy resources. The potential of solar energy and SERI's role in its development are recognized in SERI's mission statement, which reads as follows:

> "To be the nation's primary federal laboratory for solar energy research and to perform functions assigned by the Department of Energy in research, development, and testing. SERI carries out its missions by conducting and coordinating research and development on solar technologies, which private industry cannot reasonably be expected to undertake. This work advances scientific understanding and establishes a sound technological base, enabling the private sector to make well-informed choices among technology options. General guidance is provided by the National Energy Policy Plan; specific direction is provided by year-to-year authorizing documents."

We at SERI, however have condensed the ideas presented in this statement into a statement that is more succinct and direct. We refer to it as the Golden Thread Statement—"SERI: a national resource committed to leadership, excellence, and innovation in solar energy and related science and technology." And, given the necessary long-term support, SERI will remain committed to their goals and to finding solutions to the nation's future energy needs.

CONCLUSION

In closing, I would simply like to restate some of the major points made earlier.

- Our nation has a chronic need for a secure energy supply. This implies a mixed and diversified supply, utilizing indigenous resources to the degree that it is practicable to do so. And, it requires advanced energy technologies.
- Renewable energy already plays a significant role in meeting our needs and in the future will be asked to play an even bigger role in our nation's energy mix.
- We have the potential renewable energy resource, but we must maintain a consistent, stable R&D program for the next two to three decades in order to have cost effective advanced energy systems to fully use that resource.
- Finally, the Solar Energy Research Institute is fulfilling its role as the primary federal laboratory for solar research, a role which will be needed for the foreseeable future.

Senator **Fowler**. I thank you not only for the directness of the statement, but the speed with which it was delivered. Thank you, Dr. Hubbard.

I always hesitate to ask this question because it is subjective judgment without—certainly without any parameters and people see things in different ways. How would you describe the—How critical is the situation in the United States today in the renewable energy field, post tax reform and the loss of tax credits, the cutbacks that we have seen in research and development?

Dr. **Hubbard**. Well, it is a subjective subject. Certainly the industry is going through a considerable shake-down and considerable shake-up. I think there are three reasons for that. One is the temporary oil and gas glut and the impact that has had on the ability of the industry to invest, and the impact that it has had on near-term markets which has significantly moved off into the future. Disappearance of tax credits, while ultimately the industry is going to have to learn how to deal without that, it certainly has had an immediate impact that has been deleterious.

I realize that we are in a period of fiscal restraint and we have to be, so certainly the decreases in the budget up to a point were expected. But we are close to bedrock at the moment. I think there is still a sound basic research program out there all right and the basis for maintaining that, but it really can't continue to erode and expect that we are going to maintain our position.

Senator **Fowler**. Well, what should we do next, we the Government, in Govenment policy to insure that we were not putting all of our eggs in the fossil fuel basket, and give confidence to the industry that as they continue to work in the various alternative energy fields, that they have a Government that is supportive to the maximum extent possible given our budgetary restraints, and that we are interested in a comprehensive energy policy?

Dr. **Hubbard**. I will have to speak to that from my own parochial point of view as an R&D man. Naturally I am going to say that a balanced and sustained R&D budget is the most important single thing.

It is exceedingly difficult for anybody responsible for planning and laying out what a necessity has to be in a multi-year program to deal with when the budget process is erratic as it has been, and when things tend to project in an up and down way.

There is a sign on the desk of one of my people that I think is kind of interesting. It says we have embarked on a 20-year program with five-year plans, administered by two-year appointees, and keyed to an uncertain one-year budget. I think as much as anything else from an R&D perspective, that tells you what the problem is. Of course, the other problem is how does one maintain adequate balance, and how does one establish priorities and allocate resources? That is particularly important when you are dealing with a reduced resource base.

Senator **Fowler**. In my opening statement, Dr. Hubbard, one of the questions that I asked rhetorically I would like to ask specifically of you. In our efforts, in our Government's efforts, have we spread the resources, the research, even with the cut backs and the uncertainties that you accurately described, have we spread ourselves too thin in the whole renewable energy field? Should we be picking one or two renewable energy technologies, and concentrating our limited research and resources in those areas?

Dr. **HUBBARD**. That is a difficult question for me to answer for a lot of reasons. There is a point in which you get to a river that is one inch deep and three miles wide, and we are pretty close to that. When you try to make decisions on precisely where resources ought to be concentrated, that really requires a lot of deep thought and a concerted effort.

There is, I believe, more consistent planning in the program than there used to be, and there has been an effort to aggregate resources, witness the fact that to some degree SERIs own resources have been consolidated as the program funding has gone down, and that has given us a certain sense of stability.

But, yes, there is a tendency to spread things over the entire program, and we are at the point now where we are getting below critical mass in many of those technological areas.

Senator **WIRTH**. Would it possible if I might ask Dr. Hubbard to comment on a couple of factual issues? One, we used to talk about a certain percentage of our overall national energy usage coming from solar energy. I remember there was a long-term goal that we were going to reach 10, or 20, or 30 percent. Do you have some sense of what we can realistically expect that to be over the next 20 years, or should, if we were to embark on a 20 year program?

Second, do you have any understanding, or any information on what any of our international competitors are doing in the area of research, development, and perhaps movement into real working technologies in the area of solar energy?

Dr. **HUBBARD**. I will try and deal with the first question first, neither of which are particularly easy to answer. I remember I was asked whether the 20 percent goal that was set in one of the previous adminstrations was feasible or not, and I said at the time I think it is ambitious, but one out to set ambitious goals if you are addressing really severe problems.

General projections, say, 15 to 16 percent in the year 2010. It could conceivably be higher than that if it is needed to be forced in that direction. It is obviously going to be responsive to whatever changes take place with respect to oil prices until what our particular promise of the technology is.

So probably the 15 or 20 percent general area. As a goal, 10-20% is realistic and maybe a little conservative.

Senator **WIRTH**. With a considered research effort?

Dr. **HUBBARD**. Yes. It has to be sustained and it has to be planned out on a multi-year basis. It can't be as erratic as it's been.

With respect to what is going on internationally, I often get asked that question with respect to photovoltaics in particular. In consulting with my own staff on the subject, the overall investment in Japan undoubtedly exceeds our own at this point when one looks at what industry in Japan puts into it and what the government puts into it. It is our opinion, and it's probably self-serving, but I think it is accurate, that in research areas, that is research on new photovoltaic materials and understanding the basic phenomenon, the U.S. research establishment probably has a better data base and a deeper understanding than the Japanese.

I think in the area of utility applications, we may still have a slight edge, but it is true that that is beginning to erode. If you look at participation in the international market, it is no longer dominated by the U.S. as it was in 1980 or 1981. Certainly the experience they are gaining in the production of photovoltaic modules is due to their interest in consumer materials, and is likely to give them an advantage that they can exploit and carry on into major markets.

In the wind area, we are beginning to see in California the Danes become if not dominant, at least an important factor. I was in India three weeks ago where there is a major interest in wind, and they are using mostly Danish and Dutch technology.

Again, we think our research program has given us some edge in understanding some of the limiting design factors, but that's got to be carried on through to the point that it really is applicable in practical technological systems, and there is substantial competition in solar thermal, too where the Israelis are rapidly developing things.

I think across the board we still have an edge in solar science and solar technology, but in individual technologies, there are foreign competitors who are competing with us and in some areas beginning to exceed us.

Senator FOWLER. Mr. Ben Cooper, Staff Member—on the Energy Committee would like to ask some questions.

Mr. COOPER. I am interested in how these other countries, Denmark, Japan—you mentioned these—seem to be able to carry through, I believe is the phrase you used, their research and development into commercializing specific technologies, and in what area it is that the United States are weak. And what possible role the Federal Government might have in strengthening the U.S. role.

Senator WIRTH. Mr. Chairman, while Dr. Hubbard is thinking about that, the answer to that question, I have the great responsibility of carrying your proxy up to the Budget Committee which I am going to discharge at this point. If I might excuse myself and again thank you very much both for your great courtesy to us and your timeliness in allowing us to go at this point, and from your proxy. Thank you.

Senator FOWLER. You go with my blessing.

Dr. HUBBARD. I wish Senator Wirth had talked a little longer because the question you asked deserves a lot more thought than I have been able to give it. It deserves a better data base than I've got. I can only give you general impressions.

One, I think, has to do with the attitude of American industry. I came out of industry so I have some background in chemical process industries. There is a great emphasis on short-term return in U.S. industry, and that is exacerbated today because with the decline in oil prices and the impact on the oil markets, the oil companies who are major investors, in photovoltaic technology in particular, have tended to drop out. Whereas, the Japanese companies seem to be more content with lower returns and a longer planning spot.

There also seems to be one way or another a more coordinated effort between government and industry. I think in the Danish situation—again I don't know all the particulars—but I am told that governmental financing which tends to underwrite some of the investment in practical applied systems seems to be a major factor in the Danes' ability to compete abroad.

Frankly, we think the Danish systems are overengineered. That means they are operable today, but they are also relatively expensive. Without some kind of assistance and financing, they probably would not be able to compete.

Mr. Cooper. So what you are saying is we are going to repeat this kind of phenomenon unless we get the same kind of cooperation between our government and our industry, and we find some way to expand the horizon for the return? That seems to be the hallmark of the government being involved.

Dr. Hubbard. I think there are some heartening signs on the horizon. The current preoccupation that you hear, both in the Executive Branch and the Congress, relative to better return on the federal investment in R&D, the taxpayers' investment in R&D, and the look that is beginning to happen in terms of how one can put cooperative arrangements together between the government and the industry is certainly very positive. It is also true that given the long-term nature of solar markets, and the fact that most solar companies now, particularly with the oil companies tending to drop out, are small innovative companies with relatively limited financial resources. Their ability to contribute right now is quite limited.

Mr. Cooper. In the 1970s, Congress passed a series of laws that were aimed at setting stability in federal policy and getting us a little better performance from our side in terms of having stability in the policy. I am thinking of things like the Solar Photovoltaic Energy Research and Development Policy Act of 1978, and the Solar Energy Research and Development Demonstration Act of 1974, Ocean Thermo Temperature Act in 1980, and the Wind Energy Act of 1980. Have these achieved their goal of establishing a stable policy, or would you say that they have been essentially ignored by the funding committees of Congress and, therefore, haven't been useful?

Dr. Hubbard. That is probably a question I shouldn't answer, partly because I was not really part of the game in the mid and early 1970s, so I'm not totally familiar with the background. They have certainly been helpful, and they have certainly pointed us in the right direction.

Until we are able to do a little better job with budgeting and planning, I think it is very difficult for the best intended legislation to do much more than endorse a goal. I believe that is going to have to be coupled with some reforms.

Senator Fowler. It would be very helpful, Dr. Hubbard, if in the next few days you would submit for the record your ideas on what a basic, multi-year authorization might be to avoid erratic funding levels.

Dr. Hubbard. Mr. Chairman, I would be pleased to do that.

Senator Fowler. If you could do that, it would be very helpful. Thank you, Dr. Hubbard, so very much for being with us today.

Dr. Hubbard. Thank you for the opportunity.

Senator FOWLER. Now we have Dr. Peter Blair, Manager of the Energy and Materials Program of the Office of Technology Assessment.

Dr. Blair, thank you for your very, very fine testimony, and it will be made a permanent part of the record. We would like for you to summarize any comments you would like to make, and we will be able to talk a little bit.

STATEMENT OF DR. PETER D. BLAIR, PROGRAM MANAGER, ENERGY AND MATERIALS, OFFICE OF TECHNOLOGY ASSESSMENT

Dr. BLAIR. Thank you for the opportunity to share with your Subcommittee some of the findings of OTA's past and ongoing studies as they relate to the R&D needs and commercial prospects of renewable energy technologies. In particular today, I am going to focus on some of the findings of our past assessment on electric power technologies, problems and prospects for the 1990's.

I believe I sent a copy of the summary of that study in along with the testimony for your reference. And to the extent that those findings relative to the commercialization of renewable energy technologies, I want to focus on them today, as well as the results of some of our other past assessments and staff papers.

The increased use of renewable resources is clearly an important component of our nation's strategy to ensure continuity in energy supply at reasonable costs in the U.S. In the long term, renewable energy technologies offer a wide range of advantages in supplying the nation's energy needs. The promise of contributing to improved national security and reduced economic vulnerability by providing a diverse and virtually inexhaustible energy supply is the principal benefit of accelerating the commercial availability of renewables.

Other potential benefits have recently become apparent as well. For example, in the case of electric power generation, some renewables, when compared with many traditional technologies, are smaller in scale with modular designs. They permit capacity additions to be better matched to energy demand and less dependent on long term, uncertain forecasts.

The current strategy for developing renewable energy resources assumes that there is adequate time to permit private development efforts to fill energy supply gaps as they appear. This strategy, however, may not be sufficiently sensitive to the concerns that originally prompted interest in these resources.

For example, private industry developing renewables cannot be expected to include environmental concerns or considerations of foreign policy and national security prominently in corporate investment decisions. The federal government plays a principal role in encouraging and sponsoring technology development for such reasons.

A particular concern is assuring the availability of liquid fuel substitutes for oil, on which virtually our entire transportation system relies. In the longer term, finding more environmentally acceptable ways to generate electricity is also important.

The temporary fall in world oil prices has provided a window of opportunity for developing substitutes, to ensure the commercial availability of renewable energy technologies in the 1990's.

Despite the long term promise of renewables, at the current rate of development very few renewable technologies appear to be likely to be deployed in the 1990's.

Senator FOWLER. Likely to be what?

Dr. BLAIR. Sorry. Likely to be deployed extensively in the 1990's.

Senator FOWLER. Deployed?

Dr. BLAIR. Deployed, yes.

For more of these technologies, the goal of research, development, and demonstration remains to reduce costs and increase performance so that these new technologies can compete with more traditional energy sources. Cost reductions, performance improvements, and resolution of uncertainties will all occur as more effort is invested in these technologies.

The rate at which these improvements occur, however, depends on sustained progress in research, development, and demonstration. The precipitous drop in oil prices in the last few years, coupled with declining federal and private support for RD&D, and changes in the tax treatment of renewable energy investments, have severely diminished the technical progress and near-term commercial development prospects for these technologies.

The primary exception perhaps is passive solar and the use of daylight design features, which have begun to be utilized routinely in new commercial and residential building design. Photovoltaics are also being used in increasing numbers at remote sites, as well as in consumer electronics applications competitive of batteries, such as watches and calculators.

Perhaps the greatest long term role for renewables is likely to be in the use of passive solar features in commercial and residential buildings, synthetic transportation fuels from agricultural and forest crops, and finally electrical power generation from biomass, solar, and geothermal sources.

Current low prices and the possibility of sustained low prices have brought privately financed RD&D of biomass fuels to a virtual standstill. Most biomass resources are dedicated feedstocks, such as wood, waste wood, municipal solid wastes, and aquatic plants. The technologies for energy conversion include direct combustion and biochemical and thermochemical processes that produce gaseous or liquid fuels.

Increased use of commercial technologies such as wood burning and municipal solid wastes is limited by cost and environmental concerns. Increased use of the other biomass technologies is principally limited by low cost of conventional fuels. The possibility of competition from coal-based synfuels for transportation is also a factor.

Nonetheless, 55 percent of U.S. oil consumption is in automobiles and trucks, so addressing the long term possibility of oil replacement by synfuels is very important.

Renewable energy technologies are indeed important elements in the nation's long term energy supply of these technologies in the 1990's will require accelerated resources, development, and particularly demonstration. Sustained efforts to develop technologies for producing liquid transportation fuels as substitutes for oil are particularly important.

For larger scale technologies, such as in electric utility applications, cooperative industry and government demonstration efforts managed by industry have a good track record and are and will be very important, with some of the efforts specifically along these lines that I have identified in the testimony.

Many renewable energy technologies could be available in the 1990's to meet new and replacement energy demand needs through clean and efficient utilization of domestic energy resources.

Thank you, Mr. Chairman. I will be glad to take some questions.

[The prepared statement of Dr. Blair follows, the document entitled "New Electric Power Technologies; Problems and Prospects for the 1990's" has been retained in subcommittee files:]

TESTIMONY OF PETER D. BLAIR
PROGRAM MANAGER, ENERGY AND MATERIALS
OFFICE OF TECHNOLOGY ASSESSMENT

before

Subcommittee on Energy Research and Development
Senate Committee on Energy and Natural Resources

March 26, 1987

Mr. Chairman,

Thank you for the opportunity to share with your subcommittee some of the findings of the Office of Technology Assessment's past and on-going studies as they relate to the research and development needs and commercial prospects of renewable energy technology. In particular I will focus on some of the findings of our assessment *New Electric Power Technologies: Problems and Prospects for the 1990's* that relate to the commercialization of renewable energy technologies through the 1990's, as well as several other past assessments and staff papers.

THE ROLE OF RENEWABLE ENERGY TECHNOLOGIES[1]

The increased use of renewable resources is an important component of our Nation's strategy to ensure continuity in energy supply at reasonable cost for the United States. In the long term, renewable energy technologies offer a wide range of advantages in supplying the Nation's energy needs. The promise of contributing to improved national security and reduced economic vulnerability by providing a diverse and virtually inexhaustible energy supply is the principal benefit of accelerating the commercial availability of renewables. Other potential benefits have recently become apparent as well. For example, in the case of electric power generation, some renewables when compared with many traditional technologies are smaller scale with modular designs that permit capacity additions to be better matched to energy demand and less dependent on uncertain long term forecasts.

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[1] For purposes of this discussion we define renewable technologies as those that do not use conventional fossil and nuclear fuels, e.g., biomass, hydropower, passive solar, solar thermal, photovoltaics, wind turbines, and geothermal.

The current U.S. strategy for developing renewable energy resources assumes that there is adequate time to let private development efforts fill energy supply gaps as they appear. This strategy, however, may not be sufficiently sensitive to the concerns that originally prompted interest in such resources. For example, private industry developing renewables cannot be expected to include environmental concerns or considerations of foreign policy and national security prominently in corporate investment decisions. The Federal government plays the principal role in encouraging and sponsoring technology development for such reasons. Of particular concern is assuring availability of liquid fuels as substitutes for oil, on which virtually our entire transportation system relies. In the longer term, finding more environmentally acceptable ways to generate electricity is also important. The temporary fall in world oil prices has provided a window of opportunity for developing substitutes, to ensure the commercial availability of renewable energy technologies in the 1990's.

Renewable energy resources include a broad spectrum of technologies, ranging from commercially mature examples such as hydropower, some biomass technologies, solar collectors, and passive solar design features to those generally considered to be longer range options such as ocean thermal energy conversion, wave and tidal generators, solar power satellites, and others. Increased use of most of the commercially available technologies is limited in application by low cost of conventional fossil fuels or availability of resources (e.g., solar heating and hydropower respectively). Many renewable technologies are not yet commercial but have potential for considerable improvement in cost and performance and may be in a position for significant commercial application by the 1990's. These technologies include more advanced biomass technologies (including biomass-based synthetic liquid and gaseous fuels), and wider application of photovoltaics, wind, and solar thermal power.

Despite their long term promise, however, at the current rate of development very few renewable technologies appear likely to be deployed extensively in the 1990's. For most of these technologies the goal of research, development and demonstration remains to reduce costs and increase performance so that these new technologies can compete with more traditional energy sources. Cost reductions, performance improvements, and resolution of uncertainties will all occur as more effort is invested in these technologies. The rate at which these improvements occur, however, depends on sustained progress in research, development, and demonstration.

THE STATE OF COMMERCIAL DEVELOPMENT OF RENEWABLE ENERGY TECHNOLOGIES

The precipitous drop in oil prices in the last few years coupled with declining direct federal and private support for research, development, and demonstration, and changes in the tax treatment of renewable energy investments have severely diminished the technical progress and near term commercial development prospects for renewable energy technologies. The primary exception is passive solar and use of daylight design features which have begun to be utilized routinely in new commercial and residential building design. Photovoltaics are also being used in an increasing number of remote sites, as well as in consumer electronics applications competitive with batteries such as watches and calculators.

Several renewable technologies such as hydroelectric power generation and burning of wood and wood wastes account for nearly all of the world's current use of renewable energy. However, neither of these mature technologies are likely to contribute much to future expansion of renewable energy use wotjom tje U.S. Perhaps the greatest long term role for renewables is likely to be in the use of passive solar features in commercial and residential building design, synthetic transportation fuels from agricultural or forest crops, and electric power generation from biomass, solar, and geothermal sources.

Current low oil prices and the possibility of sustained low oil prices have brought privately financed research, development, and demonstration of biomass synfuels to a virtual standstill. Most biomass resources are dedicated feedstocks, such as short rotation wood, waste wood, municipal solid waste (MSW), herbaceous crops, or aquatic plants. The technologies for energy conversion include direct combustion and biochemical or thermochemical processes that produce gaseous or liquid fuels. Increased use of commercial technologies such as wood burning and MSW is limited by cost and environmental concerns. Increased use of other biomass technologies, largely to produce synfuels, is principally limited by low cost of conventional fuels. The possibility of competition from coal-based synfuels for transportation fuels is also a factor. Nonetheless, 65 percent of U.S. oil consumption is in automobiles and trucks, so addressing the long term possibility of oil replacement by synfuels is still very important. One important but often under-stressed reason is that oil imports account for nearly a third of our negative international balance of payments.

OTA's most recent studies on the commercial development prospects of new renewable technologies have focussed on power generation applications. As with biofuels technologies, low oil prices and excess electric power generating capacity in many regions (and hence in many cases low avoided cost buyback rates under the Public Utility Regulatory Policies Act of 1978 -- PURPA), have slowed the development of new renewable power technologies and deployment of early commercial designs of these technologies. In spite of this, photovoltaics, wind, and geothermal still show some promise for the 1990's.

Photovoltaics (PV) technology has developed rapidly in recent years, but the technical challenge of developing a PV module that is efficient, long-lasting and economically competitive remains. Industry activity remains intense. Technical progress and deployment of photovoltaics in the U.S. were, however, slowed considerably by termination of the Renewable Energy Tax Credit (RTC), by other changes in the tax law, by declining avoided costs, and by declining direct federal research and development support. About 40 U.S. firms sold 10 MW of PV systems in 1986. Japanese and German firms together sold about 13 MW. Aided by interim markets of specialized remote applications and consumer electronics, however, PV's could develop to the point where competitive grid-connected applications begin to appear in the 1990's. Potential for more extensive applications in remote areas is possible even sooner.

The U.S. wind turbine industry was also dramatically affected by the termination of the renewable energy tax credits (RTC) and other tax law changes. For example, the number of wind developers in the U.S. fell from 112 in 1984 to fewer than 40 by mid-1986 and only a handful today. Ninety percent of the turbines built in 1986 were made by 4 companies. Over the early 1980s, capital costs have dropped rapidly and performance improved swiftly. Improvements are expected to continue, and the cost of electric power from wind turbines in high-wind parts of the country is competitive. These improvements, however, are being seen more quickly in foreign turbines. For example, in California (where 98 percent of the U.S. wind turbine capacity of about 1,100 MW is installed) the capacity factor, generally measuring equipment reliability, for foreign turbines was 17% in 1986 while that of U.S. manufactured turbines was only 10%. The rate of continued technology improvement will be heavily influenced by future trends in the avoided costs or "buy-back rates" offered by utilities to nonutility electricity producers. Should these costs continue to be low or uncertain, technological development and application will be retarded. Conversely, high avoided costs, stimulated perhaps by rising oil and gas prices or shrinking reserve margins of generating capacity, might substantially accelerate their development.

Although geothermal development has been substantial compared to many renewable technologies, most of this development has occurred at The Geysers in California, a unique high-quality dry steam resource (one of only seven known in the world) that can be tapped with mature technology. There is currently about 2000 MW of geothermal capacity in the U.S, most of which is at The Geysers. All other geothermal resources in the United States require less developed technology to generate power. Two developing geothermal technologies, though, are currently being demonstrated on a small scale and show promise for commercial applications in the West. Current evidence indicates that these technologies--dual flash and binary systems--are very close to being commercial, and that cost and performance will be competitive. Small binary units (about 10 MWe) are already being deployed commercially. These developments, particulary sustained successful commercial demonstrations, coupled with the possibility that the technologies could be put in place with lead-times of 5 years or less, suggest that they could be an important source of new power generating capacity in the West by the end of the century, if the new capacity is needed.

Of the solar thermal power generation technologies, solar parabolic dishs offer the most promise over the next 10-15 years, at least in areas of high levels of direct insolation, such as the Southwest. While some demonstration and subsidized commercial units already are operating, commercial applications will require further demonstrations over extended periods of time. The likelihood of such demonstrations, however, appears now to depend on the availability of some kind of subsidy. Early development of the technology depended heavily on the RTC. Several designs of solar thermal parabolic troughs are being developed and a commercial unit, also benefiting from the RTC, was operating in Southern California by early 1985. Troughs, and other solar thermal variations, including central receivers and solar ponds, however, are likely to be longer term options.

CURRENT AND FUTURE STATE OF ALTERNATIVE TECHNOLOGY INDUSTRY

Many renewable energy technologies are being developed by a much wider range of firms than has traditionally been the case in the energy industry. Moreover, many firms involved in developing and deploying some of these technologies, to the extent that they are being deployed, are small independent firms, less than 3 years old. For example, the wind industry's equipment sales have for the most part been to third-party financed wind parks selling power to utilities under PURPA; many of these parks have been developed by the wind manufacturers themselves. Other renewable technology developers are large aerospace, petroleum, or other companies that have also not traditionally dealt with electric utilities or other energy markets, and many of them are only beginning to develop working business relationships with them.

Many renewable technologies are in a transition phase of their development, i.e., between pilot- and commercial-scale demonstrations or early commercial units. Some of these technologies are progressing through this transition aided by the existence of auxiliary markets (in many cases foreign) rather than the conventional energy markets. For example, which the PV technologies that will ultimately begin to penetrate grid-connected power generation markets is not yet clear, the various candidates (flat plate, amorphous silicon, concentrators, etc.) are maturing in other markets such as consumer electronics or remote power applications.

As most renewable technologies mature and the relationships of vendors and manufacturers with potential users develop, the nature of negotiated agreements between the parties initiating commercial demonstrations or early commercial units may dictate the pace of commercial deployment of the technologies. For example, the allocation of risks in the form of performance or price guarantees or other mechanisms will be especially important for the electric utility market. In many successful early ventures, an equipment manufacturer's agreement to hold an equity position in early commercial projects has been viewed by many utilities as an adequate performance guarantee.

The pressures of competition from foreign vendors, many of which are heavily supported by their governments, as well as the current lack of U.S. demand for renewable technologies coupled with changes in favorable tax treatment throw into question the continued commitment of U.S. firms to developing these technologies. For some technologies, such as wind turbines, solar thermal-electric technologies, and photovoltaics, the survival of some domestic firms may be at stake. Indeed, foreign competition has been a principal factor in the shakeouts in the wind turbine and photovoltaics industries. In some cases, e.g., photovoltaics, foreign markets are considered to be interim markets for technologies as they mature to the point where they can compete in the U.S. grid-connected power generation market. For other technologies, such as synthetic transportation fuels from biomass, most U.S. firms historically involved in development find their investment decision horizen too short to justify very much sustained technology development. As a result, for many renewable technologies, many domestic firms may not be able to compete in world markets over the next decade.

RESEARCH AND DEVELOPMENT: THE POLICY CONSEQUENCES

Sensitivity to Energy Demand Growth

While the long-term potential of the developing renewable technologies is substantial, those applied to electric power generation have the most promise for application in the 1990's. If electricity demand growth declines to an average annual rate of 2.5 percent or less through the 1990's--the average annual growth rate from 1973 to 1984 was 2.5 percent--utilities' needs for new generating capacity are likely to be modest. In that case the development schedules and lead times currently associated with the alternative technologies discussed above need not be significantly accelerated. It is possible, however, that electricity demand may grow faster, in which case utilities in some U.S. regions may require substantially more new generating capacity. Demand growth projections for the 1990's range from 2-5 percent. Perhaps more importantly, the demand growth rate is also likely to vary significantly by region.

At the current rate of development, most of developing renewable technologies will not be in a position to meet either new or replacement demand in the 1990's. Under circumstances such as accelerated demand growth, however, the interest in conventional and developing technologies that offer the flexibility of short lead times and modular design features might be sharply increased. In addition, increased environmental concern over acid rain, CO_2, and nuclear power could limit increased deployment of conventional coal and nuclear options and could, under some circumstances, force expensive retrofits of existing powerplants.

Research, Development, and Demonstration

Perhaps foremost among the conditions necessary to sustain renewable technology development in the U.S. is a continued Federal presence in research, development, and demonstration. While many renewable technologies are no longer in the basic research phase, development hurdles are still formidable and the importance of research, development, and demonstration remains high; if these hurdles are overcome the result could be a quick change in competitive position for many of these technologies. For example, with current cost and performance estimates, proof of satisfactory reliability during a commercial utility-scale demonstration of PV powerplants could increase very quickly deployment of PVs among electric utilities .

A critical milestone in commercial acceptance of a renewable energy technology is completion of a successful demonstration program. While there is considerable debate in the energy industry over what constitutes an adequate demonstration, two basic categories are often distinguished: One is a proof-of-concept phase which provides the basic operational data for commercial designs as well as test facilities designed to prove the viability of the technology under nonlaboratory conditions and to reduce cost and performance uncertainties. The other involves multiple applications of a more or less mature technology designed to stimulate commercial adoption of the technology. Generally, activities in the first category are necessary for demonstrating commercial viability and activities in the second category are necessary for accelerating commercialization.

The length of the appropriate demonstration period will vary considerably by technology. However, adequate demonstration periods (perhaps many years for larger scale technologies) are crucial to promoting investor confidence. Moreover, the nature of the demonstration program--i.e., who is participating, who is responsible for managing it, and the applicability of the program to a wide variety of utility circumstances--is of equal importance. Among the most successful demonstration ventures have been and are likely to continue to be cooperative ventures between industry (e.g., manufacturers and either utilities or nonutility power producers) and the Federal Government, with significant capital investments from all participants in the venture. The current geothermal demonstrations are good examples. In particular, for larger scale technologies in utility applications, cooperative industry-government demonstration efforts managed by the utilities have a good track record. For accelerated deployment, similar projects would be required for photovoltaics and central receiver solar thermal powerplants.

Generally, our work has found that successful demonstration projects should have the following characteristics:

- The private sector should have considerable influence in the selection of technologies for demonstration as well as principal responsibility for demonstration program design and management of the demonstration project itself.
- Private sector proprietary rights and ownership should be preserved, provided that such protection does not inhibit timely development of the technology.
- Cost sharing between government and industry has generally proved successful in ensuring both careful selection of the most competitive projects and timely completion of the projects.
- Federal government commitments to a demonstration program should be stable and predictable, i.e., once made, such commitments should be honored for a sufficient period in order to convince developers that government is a "reliable partner."
- First-of-a-kind, full scale demonstration facilities should include support by all partners involved in the demonstration program for not only plant engineering and construction but also for extended plant operations.

The relationship between utilities and public utility commissions in early commercial applications of new generating technologies is an important factor that will affect the deployment of many renewable technologies in the 1990's. In particular, increased research, development, and demonstration activity will require utilities and utility commissions to agree on appropriate mechanisms for supporting such activities. Direct support alone from the rate base for research activities (e.g., the allowance for contributions to the Electric Power Research Institute) may be desirable and important, but they are not sufficient to assure extensive deployment of these technologies by the 1990's. Much larger commitments, however, that involve large capital investments such as major demonstration facilities may only be justified by a sharing of the risk between ratepayers, stockholders and, if other utilities would benefit substantially, taxpayers. One mechanism for supporting such projects is to finance a portion of a proposed project with an equity contribution from the utility and the rest through a "ratepayer loan" granted by the public utility commission. The public utility commission might argue that a candidate demonstration project is too risky for the ratepayer to be subsidizing it, particularly if other utilities could benefit substantially from the outcome if successful and are not contributing to the demonstration, i.e., sharing in the risk. In such cases, there could be a Federal role; for example, the ratepayer contribution to the demonstration could be underwritten by a Federal loan guaranty.

CONCLUSIONS

Renewable energy technologies are important elements in the Nation's long term energy supply strategy. Increased contribution to U.S. energy supply of these technologies in the 1990's will require accelerated research, development and, particularly, demonstration. Sustained efforts to develop the technologies for producing liquid transportation fuels from biomass as substitutes for oil are particularly important. For larger scale technologies, e.g. in electric utility applications, cooperative industry-government demonstration efforts managed by industry have a good track record and are be very important; the current geothermal demonstrations are good examples. With the efforts outlined above, many renewable energy technologies could be available in the 1990's to meet new and replacement energy demand needs through clean and efficient utilization of domestic energy resources.

* * *

Mr. COOPER. I think you just closed by saying many of these technologies could be available in the 1990's. And if I remember, when you began you said at the current rate of development, very few technologies would be deployed.

Dr. BLAIR. That is right.

Mr. COOPER. What are the main reasons for your prediction that they are not going to be deployed?

Dr. BLAIR. I think in the case of electric power applications, for example, in the solar, wind, and geothermal areas, the markets have historically depended upon demonstration of these technologies to a very conservative client, if you will.

And I think the move from the research phase into the commercial applications phase is the primary obstacle that many of these technologies have to overcome.

Mr. COOPER. What do you take to be the main reason why we are not doing more in demonstration of the technologies at the commercial level?

Dr. BLAIR. Perhaps a sort of national sense of complacency, with low oil prices, has led to a lessened sense of urgency. And I imagine that other factors weighing in the research and development efforts, budget concerns and the like, have pushed demonstration efforts, which are in some cases very costly, particularly for the centralized technologies.

Mr. COOPER. Do demonstration efforts have to be very costly? Is it not their nature?

Dr. BLAIR. No, not necessarily, particularly for the smaller scale technologies. And we have had some success with those in the past in terms of cost sharing.

By costly, you mean to the federal government?

Mr. COOPER. To the federal government, right, because I presume that is the reason for the long range, high risk research which takes us away from demonstration towards research.

Dr. BLAIR. Well, clearly that takes us away from demonstration. There are ways, I think, that have been successful, not so much in the renewable area, I think with the possible exception of the geothermal demonstration examples—the cool water example for integrated coal gasification combined cycle is not a renewable, but clearly a successful cooperative demonstration effort, was a kind of paradigm that perhaps others might be able to follow.

Mr. COOPER. Refresh my memory, but I think in those cases, were not the utilities involved in the cooperative work?

Dr. BLAIR. Indeed, utilities would be very important clients to many of these technologies down the road. Utility involvement in these demonstration efforts is really essential for accelerated commercialization of these technologies.

Mr. COOPER. And I gather we are not involving utilities extensively in solar or renewable demonstration programs. Is that one of the reasons why we do not have as much emphasis on demonstration?

Dr. BLAIR. Yes, I think that is true. Traditionally, utilities are not very much involved in research and development. In this country, I think it is on the order of six-tenths of one percent of total revenues is invested in R&D in the nation's utilities.

Traditionally, they have relied upon the equipment manufacturers to carry out their research and development. The equipment manufacturers, in the face of falling electricity demand, are not really willing to invest in new research and development. So utility applications of new technologies have fallen off considerably.

Mr. Cooper. Do you think if utilities saw a way to participate directly in some of these projects, perhaps the way we have encouraged people through the Public Utilities Regulatory Policy Act to invest in some of these technologies, do you think that might be an incentive for utility involvement in demonstration that would not cost the federal government a lot of money?

Dr. Blair. Incentives for utility involvement would certainly be essential to accelerating the development of these technologies, and there are a variety of ways in which that could be done. One would be allowing utilities to participate in PURPA kinds of projects. Another, the so-called ratepayer loan concept, where perhaps the commercial application is funded by, in effect, a loan at a higher rate from the public utility commission. If the public utility commission is concerned about that, the payback of that essentially ratepayer loan, it could be then subvened or guaranteed by the federal government.

Mr. Cooper. Could you provide us with a list of some of these incentives, based on your knowledge and research in this area?

Dr. Blair. Sure.

[The information follows:]

RENEWABLE ELECTRIC POWER TECHNOLOGIES:

RESEARCH AND DEVELOPMENT OPTIONS FOR ACCELERATING COMMERCIAL DEVELOPMENT

Staff Paper
Prepared by the

Energy and Materials Program
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Renewable Electric Power Technologies: Research and Development Options for Accelerating Commercial Development[1]

INTRODUCTION

Renewable energy technologies offer a wide range of advantages in helping to supply the Nation's energy needs. First and foremost, accelerating the commercial availability of renewables offers the long-term promise of improved national security and reduced economic vulnerability through a diverse and virtually inexhaustible energy supply. Other potential benefits have recently become apparent as well. For example, renewable electric power generation systems tend to be smaller than traditional technologies. Their reduced scale, coupled with modular designs, permit capacity additions to be matched more closely to energy demand, and thus are less sensitive to uncertain long term forecasts. Moreover, the need to diversify electricity supply options is now being pursued not only to reduce dependence on oil, but also in anticipation of possible future circumstances, such as more stringent control of air pollution emissions or increased availability of natural gas

An increased contribution of renewable power technologies before the turn of the century will require accelerated research and development, however. This is because at the current rate of development very few renewable energy technologies are likely to be deployed extensively in the 1990's. Current U.S. strategy for developing renewable energy resources assumes that there is adequate time to rely on private development efforts to fill energy supply gaps as they appear. This strategy, however, may not be sufficiently sensitive to the concerns that originally prompted interest in renewables. For example, private industry cannot be expected to develop currently non-competitive renewables in anticipation of future price increases of liquid fossil fuels or future environmental concerns. Nor do considerations of foreign policy and national security figure prominently in corporate investment decisions. The Federal Government has traditionally been responsible for encouraging and sponsoring technology development for such reasons.

The temporary drop in world oil prices has provided a window of opportunity for research and development that would ensure the commercial availability of renewable energy technologies in the 1990's. In this staff paper we revisit and update a number of the policy options relating specifically to research, development and demonstration (RD&D) that were considered in OTA's 1985 report *New Electric Power Technologies: Problems and Prospects for the 1990's*. In particular we consider three major categories of RD&D initiatives that could accelerate the commercial deployment of renewable power technologies in the 1990's: (A) **Reduce Capital Cost, Improve Performance and Resolve Uncertainty,** (B) **Encourage Non-Utility Role in Commercializing Developing Technologies,** and (C) **Encourage Increased Utility Involvement in Developing Technologies.**

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[1] Portions of this staff paper are excerpted from U.S. Congress, Office of Technology Assessment, *New Electric Power Technologies: Problems and Prospects for the 1990's*, OTA-E-246, July 1985; and "Commercialization of New Electric Power Technologies: Experience With the Renewable Energy Tax Credit," OTA Staff Memorandum, October 1985.

RESEARCH AND DEVELOPMENT FOR NEW ELECTRIC POWER TECHNOLOGIES

Electric utilities on average currently spend less than one percent of gross revenues on research and development (R&D), considerably less than most other capital intensive industries (see Table 1). This figure includes their support of the Electric Power Research Institute. Electric utilities and public utility commissions point out that, with the exception of nuclear power, equipment manufacturers and vendors have traditionally carried the principal burden of R&D for the power industry. But, with the decline in new equipment orders in recent years, manufacturers are less likely to commit R&D to new products for which strong markets are very uncertain. As a result, if R&D activity in new generating technologies is to continue, at least a portion of the burden will probably have to shift to the utilities themselves. As pressures on utilities to consider new technologies mount, how public utility commissions treat the costs of research, development, demonstration and of early commercial applications is a pivotal issue, in gauging the relative effectiveness of public policy initiatives for accelerating the use of new power technologies.

Table 1
Private Sector Research and Development Expenditures
(percentage of gross revenues)

Industry	R&D Expenditure (% of Gross Revenues)
Aircraft and Missiles	4.2%
Electrical Equipment	4.3
Machinery	5.2
Chemicals and Allied Products	4.3
Motor Vehicles	3.2
Metals and Mining	1.5[a]
Electric Utilities (investor-owned)	0.4[b]

[a] Business Week, "R&D Scoreboard," June 23, 1986, pp. 139-156.
[b] Sherman Feher, Electric Power Research institute, personal communication, April 28, 1987.

While utility investment in both R&D and in commercial applications of new electric generating technologies in the United States is relatively small, the number of non-utility investors generating power under the provisions of the Public Utility Regulatory Policies Act (PURPA) of 1978, has increased rapidly in the last few years. Tax incentives for cogeneration[2] and small-scale power production, and the increased availability of natural gas coupled with supportive regulatory treatment under PURPA, have led to considerably increased activity in non-utility generation in some regions, particularly those of highest load growth and fuel cost (the West and Southwest). This reemergence of non-utility power production as a growing industry in America has provided an important test bed for some new generating technologies. While much of this investment to date has gone into cogeneration using conventional technologies, the application of new generating technologies is steadily increasing in some utility service areas (e.g., California). The degree to which non-utility investment in new generating technologies affects the total generation mix is also an important ingredient in the future of the U.S. electric power system.

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[2] Cogeneration refers to simultaneous production of steam for process heat and electricity.

RESEARCH AND DEVELOPMENT POLICY OPTIONS

GOAL A: REDUCE CAPITAL COST, IMPROVE PERFORMANCE AND RESOLVE UNCERTAINTY

Present cost and performance characteristics of many renewable power generating technologies generally do not yet compare favorably with either conventional generating options or other strategic options such as load management and life extension of existing power plants. Of particular concern are the uncertainties in cost and performance anticipated in early commercial applications. The following are alternative policy options aimed at reducing cost, improving performance, and resolving uncertainties in both cost and performance.

A1: Increase Federal Support of Technology Demonstration

A critical milestone in both utility and non-utility acceptance of new technology is completion of a commercial demonstration program. There is considerable debate in the industry over what constitutes a demonstration program, but usually two basic categories are distinguished. One is a proof-of-concept phase that will provide test facilities and the basic operational data for commercial designs intended to prove the viability of the technology under non-laboratory conditions and to reduce cost and performance uncertainties. The other involves multiple applications of a more or less mature technology that will stimulate its commercial adoption. In theory, the distinction seems clear; in practice, it sometimes is not. Generally, activities in the first category are necessary to demonstrate *technical feasibility*, and activities in the second category are necessary to demonstrate *commercial readiness* and thus to accelerate acceptance by utilities or non-utility power producers.

The length of the appropriate demonstration period will, of course, vary considerably by technology. However, adequate demonstration periods (perhaps many years for larger-scale technologies) are crucial to promoting investor confidence. Moreover, the nature of the demonstration program -- who is participating, who is responsible for managing it, and the applicability of the program to a wide variety of operating circumstances -- is crucial, if utilities are eventually to buy the technology.

Many electric utility decision-makers argue that the perceived and real obstacles to the adoption of advanced generating technologies can be removed by "well managed federally sponsored incentives and projects."[5] A cooperative research and development partnership between government and industry has proven to be a key ingredient to success in many such ventures. Such cooperative demonstration programs should have the following characteristics:

- The private sector should have considerable influence in the selection of technologies for demonstration, as well as principal responsibility for demonstration program design, and management of the demonstration project itself.

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[5] I. R. Straughn, Director of Research and Development, Southern California Edison Company, Testimony before the House Committee on Science and Technology, Subcommittee on Energy Development and Applications, June 13, 1984.

- Private sector proprietary rights and ownership should be preserved, provided that such protection does not inhibit timely development of the technology.
- Costs should be shared between government and industry to ensure both careful selection of the most competitive projects and timely completion of the projects.
- Federal Government commitments to a demonstration program should be stable and predictable; i.e., once made, such commitments should be honored for a period sufficient to convince developers that government is a "reliable partner."
- First-of-a-kind, full scale demonstration facilities should include support by all partners involved in the demonstration program for not only plant engineering and construction but also for extended plant operations.[4]

Smaller modular plant designs, where possible, are very attractive for demonstration projects because they normally require a smaller capital commitment than large, central station designs. In addition, successful demonstration projects have included active participation from a wide range of private sector interests such as architect-engineering firms, equipment manufacturers, and the utilities themselves when appropriate.

A2: Shorten Project Lead Times and Direct R&D to Near-Term Commercial Potential

Under conditions of higher load growth in the 1990's or as existing power plants are retired, research, development and demonstration would have to be increased or refocused now to accelerate the deployment of early commercial units of new generating technologies. The primary concerns are resolving cost and performance uncertainties and shortening lead times for deploying early commercial units. These, of course, include attention not only to the technologies themselves, but also to the manufacturing techniques and equipment necessary to produce the technologies.

Some renewable technologies, such as photovoltaics, solar thermal parabolic dishes, and wind turbines, are relatively small in generating capacity and are likely to have shorter lead times than larger conventional plants. Before these technologies could be adopted widely, however, research is needed to reduce cost and to resolve cost and performance uncertainties that concern utility decision-makers and non-utility investors. These uncertainties in cost and performance stem largely from the lack of sufficient commercial operating experience. Utility decision-makers, in particular, are now wary of new technology after their experience with nuclear power, and impose rigorous performance tests on technology investment alternatives.

For these technologies, one approach to accelerating development would be to increase or concentrate Federal R&D efforts on them. This could be particularly effective for photovoltaics, solar thermal parabolic dishes, and advanced small geothermal designs. However, even under such an approach, as these technologies become competitive commercially, the participation of the private sector should increase.

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[4] Adapted from D. Spencer, Electric Power Research Institute, "Remarks on the Importance of a Federal Government Role in Supporting Demonstration Scale Facilities for Fossil and Renewable Energy Technologies," Testimony presented to the House Committee on Science and Technology, Subcommittee on Energy Development and Applications, June 7, 1984.

Other renewable energy technologies (e.g., large geothermal plants or solar thermal central receivers) need little or no RD&D for deployment in the 1990s. However, these technologies tend to have long preconstruction and construction lead times--seven to eleven years or more in some cases. Therefore, the transition from demonstration to commercial units and the construction lead time will have to be accelerated if these technologies are to help meet demand growth in the 1990s. Variations in basic designs, or more advanced designs may, of course, require additional R&D.

A3: Increase Assistance to Vendors Marketing Developing Technologies in Foreign Countries

The new generating technologies that appear to show the most promise for substantial deployment in the 1990's are those that currently serve or have the opportunity to serve markets other than the domestic utility grid. Foreign markets for generating equipment can be especially important while domestic demand for new electric capacity continues to be low and while the cost and performance of these technologies are uncertain in grid-connected applications. Efforts on the part of the U.S. government to assist in establishing access to foreign markets for new generating equipment could be very important to the near time viability of some of these technologies. In particular, some renewable energy technologies may be economic sooner in developing countries than in the U.S., e.g., photovoltaics in remote power applications. Efforts to promote foreign markets might include loan guarantees, information dissemination and assistance with the formation of renewable export trading companies and with joint venture and licensing applications in foreign countries.

The pressures of competition from foreign vendors, many of which are heavily supported by their governments, as well as the current lack of U.S. demand for some of these new technologies in grid-connected power generation applications brings into question the continued commitment of U.S. firms to developing these technologies. This concern is heightened by pending changes in favorable tax treatment for renewable energy sources. The survival of some domestic firms working on technologies such as wind, solar thermal electric, and photovoltaics (at least those focusing on concentrator technologies), may be at stake due to a lack of ability or willingness to compete in world markets over the next decade. However, they may need those markets until their technologies can compete in the U.S. grid-connected power generation market.

A4: Increase Resource Assessment Efforts for Renewable Energy and CAES Resources

In those regions where renewable energy sources show promise for commercial applications, a well defined resource is essential for assessing the economics of proposed wind, geothermal, and solar power generating projects. For example, the energy generated by the same wind machines using different distributions of the same annual mean wind speed can vary by several hundred percent; an untested site may require up to three years of data to confirm the extent and nature of the wind resource at that site.

Reliable resource data lessen the uncertainty in energy production and hence the risk of insufficient project revenues. Some industry observers feel that, at least in the case of wind, improved knowledge about wind resources, primarily their location and intensity, is essential to the development of wind energy. Lack of a detailed resource base is also an important factor in geothermal development and, to a lesser extent, in solar thermal electric and photovoltaic development.

A5: Improve Collection, Distribution, and Analysis of Information

A serious disadvantage facing all the developing technologies is that the decisionmakers -- investors, regulators, academicians, the general public and others -- lack adequate information on the technologies and their markets. Non-utility market information, in particular, is generally not available because these markets are not yet well developed. The lack of information increases the general level of uncertainty and risk, and favors better-known conventional technologies and markets.

Programs designed to deliver accurate and useful information in a timely manner to the relevant individuals and groups would be helpful in accelerating deployment of the technologies. Also, efforts to increase the capability to use the information properly could be effective. Such efforts might include training, the development of appropriate analytical methods, and acquainting people with the technology through demonstration projects.[5]

GOAL B: ENCOURAGE NON-UTILITY ROLE IN COMMERCIALIZING DEVELOPING TECHNOLOGIES

Since the early 1970's, the Federal policy for encouraging the development of a renewable energy industry has centered on an active R&D program coupled with the Renewable Energy Tax Credits (RTC) to spur commercial applications. OTA has found that with declining direct support from Federal R&DD programs, the pace of renewable technology development has slowed considerably without tax incentives such as the RTC.[6] Indeed, lack of the RTC, compounded by other factors such as excess generating capacity in many regions and falling avoided costs under PURPA due to low oil prices, has meant that only the most mature renewable technologies at the best resource locations are being pursued. Even with tax incentives, the application of many renewable technologies will be highly regionally dependent in the 1990's. Nonetheless, in regions where the wind, solar, and geothermal resources are of high quality, the renewables could be important contributors to both new and replacement generating capacity. OTA's previous report discusses other options for increasing the role of non-utility power producers, including improving non-utility access to transmission capacity, developing clearly defined and/or preferential avoided energy cost calculations under PURPA, and standardizing interconnection requirements.[7]

GOAL C: ENCOURAGE INCREASED UTILITY INVOLVEMENT IN DEVELOPING TECHNOLOGIES

As noted earlier, electric utilities typically spend relatively little on R&D relative to other capital intensive industries. If R&D activity in new generating technologies is to continue, at least a portion of the burden may fall on the utilities themselves. With environmental and other pressures on utilities to consider new technologies, how public utility commissions treat the costs of research, development, demonstration and early commercial applications is a pivotal issue. The following are alternative strategies aimed at improving this regulatory environment.

C1: Increase Utility and Public Utility Commission Support of RD&D

Increased RD&D activity in new generating technologies will require utilities and utility commissions to agree on appropriate mechanisms for supporting such activities. Direct support from the rate base (such as the allowance for contributions to the Electric Power Research Institute) is not now at a level that would cause significant deployment of new technologies by the 1990's. Allowance of or even encouragement of a higher percentage of annual revenues to support RD&D activities could be an important step in accelerating commercial applications of new technologies.

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[5] For an informative discussion of the importance to public utility commissions of the collection, distribution and analysis of information, see: S. Wiel, Commissioner, Public Service Commission of Nevada, Statement before the Subcommittee on Energy Development and Applications, Committee on Science and Technology, House of Representatives, United States Congress, Mar. 5, 1985.

[6] U.S. Congress, Office of Technology Assessment, "Commercialization of New Electric Power Technologies: Experience With the Renewable Energy Tax Credit," October 1985.

[7] Office of Technology Assessment, *New Electric Power Technologies*, op. cit., 1985.

Larger RD&D commitments that involve capital investments for major demonstration facilities may only be justified by a sharing of the risk among ratepayers, stockholders and -- if other utilities would benefit substantially -- taxpayers. One mechanism for providing such support is to finance a portion of a proposed project with an equity contribution from the utility and the rest through a "ratepayer loan" granted by the public utility commission. The public utility commission might argue that a candidate demonstration project is too risky for the ratepayer to subsidize, particularly if other utilities could benefit substantially from the outcome but are not contributing to the demonstration, i.e., sharing in the risk. In such cases, there could be a Federal role. For example, the ratepayer contribution to the demonstration could be underwritten by a Federal loan guaranty, thus transferring at least a portion of the investment risk from the ratepayer to the taxpayer.

Finally, because high interest rates and high capital costs have discouraged utilities from making investments in new generating capacity,, a wide variety of regulatory changes have been suggested that would make it easier to resume construction programs. These include: 1) rate base treatment of utility assets that take inflation into account--sometimes called "trending" the rate base;[8] 2) allowance of some or all of construction work in progress (CWIP) to be included in the rate base; and 3) adoption of real rates of return on equity commensurate with the actual investment risk. These options are all aimed at smoothing rate increases (prevention of so-called "rate shock") and providing more financial stability for utilities. These options would, however, reduce the attractiveness of smaller, modular generating technologies relative to larger units because they transfer some of the investment risk from the stockholder to the ratepayer. While all capital projects--large or small--would benefit by this risk transfer in terms of lower capital costs, the larger the project the greater the net savings to the utility. Whether this is sufficient to outweigh the benefits of smaller units in a period of uncertain demand growth would depend on the particular utility and its longer term outlook.

C2: Promote Involvement of Utility Subsidiaries in New Technology Development

Some electric utilities are using (and many are considering) regulated or unregulated subsidiaries (or other holding company structures) to initiate new technology projects. These financial arrangements are useful for projects that are attractive investment opportunities but are riskier than more traditional utility investments (i.e., the utility's allowed rate of return is not commensurate with the project's perceived financial risk). In practice, this usually amounts to a situation where the public utility commission agrees to permit a project to proceed but does not give assurances that the entire final project cost will enter the rate base.

Using an subsidiary operating outside of traditional rate regulation mechanisms to carry out new technology projects allows utilities to finance such projects with sources from the capital markets because higher rates of return can be offered to attract capital. It is also one example of how utilities are diversifying into other lines of business. Electric utility diversification activities are already widespread and growing. Most of these activities (74 percent according to an Edison Electric Institute survey) involve fuel exploration and development, real estate, energy conservation services, fuel transportation, district heating and cogeneration, and appliance sales. A small percentage (6 percent) involve alternative technology projects. Generally, diversification has led to:

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[8] Trended rate base proposals are discussed in OTA, *Nuclear Power in an Age of Uncertainty*, op. cit., 1984.

1. A higher return for investors; increase in price-earnings ratio and, as a result, an improved standing in the financial community and a lowering in the cost of capital. Diversified utilities have consistently outperformed non-diversified utilities in the stock market.
2. More efficient use of company assets including labor, customer base, computational facilities, services.
3. Diversification, protection, and stable pricing of fuel supplies through fuel acquisition activities and alternative technology projects.
4. An ability to take advantage of favorable tax benefits not afforded to regulated public utilities.

The problems of potential cross-subsidization of unregulated projects from regulated interests has to be monitored closely by public utility commissions as utilities diversify.

In OTA's assessment of new electric power technologies,[9] several other initiatives related to accelerating technology development in electric utility applications were identified. These include resolving siting and permitting questions for developing technologies; re-examining a number of legislative initiatives such as potential revisions to PURPA; and taking steps to increase competition in the electric power industry.

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[9] Office of Technology Assessment, *New Electric Power Technologies*, op. cit., 1985.

Mr. Cooper. Perhaps ranking them as to what you think are the most effective, and giving us an indication of where the costs might lie for giving these various incentives? That would be very helpful.

Dr. Blair. Certainly. We discussed a lot of them in the new electric power report, but there have been some changes since this report was released. So certainly it is worth updating.

Senator Fowler. In your opinion, Dr. Blair, is there a specific omission in the policy of the federal government that is causing this lack of bridge between basic R&D and what you described as the demonstration of the technology, its commercial applications?

Dr. Blair. Well, I think what is lacking is a carefully orchestrated way in which industry and government can cooperate in these demonstration projects. That is the principal impediment in my view for at least those applications that are deployable in the 1990's.

If we are content to live with commercialization of these technologies beyond the 1990's—my metaphor for this is like investing in flood insurance. We are sort of living in the flood plain of potentially accelerated load growth in the 1990's, or not being able to meet electric demand in the 1990's, in which case we have three options.

We can either wait for the big dam up the river to be built, that is wait for traditional large-scale central station plants to be built, if they can be built, or perhaps try to accelerate or reduce their construction lead times.

Or second, we can in effect pray that it doesn't rain, that is, hope that load growth is so low that we do not need any of these options accelerated to be used.

Or third, we can, in effect, invest in flood insurance, that is invest in a range of these alternative technologies, some renewable and some other kinds of technologies, that can be called upon in the 1990's to fill this gap.

Senator Fowler. The evidence is in government policy, certainly in the last ten years. We are praying it will not rain.

Dr. Blair. I think that is fair to say.

Senator Fowler. While you are here, I cannot help but ask you, in your capacity with the Office of Technology Assessment, is it an accurate assumption that we—that our government is basically—has basically determined that there will be no new nuclear power plants built in this country?

Dr. Blair. I am not sure I can speak for the government.

Senator Fowler. I am not trying to put you on the spot, but I guess I am just sort of asking. I know you talk about these things down there all the time. If you want me to be more precise: Under what conditions do you see that nuclear plants will be built in this country?

Dr. Blair. I can recount some of the results of our 1984 study on the future of nuclear power, which essentially said the nuclear industry in its current form—that is, in terms of large central station nuclear capacity—given the investment decision, attitudes of utilities in this country, without changes in perhaps a variety of other ways, very few utilities are likely to invest in large scale central station nuclear power plants over the next decade.

Senator Fowler. That is a function, is it not, of cost, a cost decision, far more than one of safety considerations?

Dr. **Blair**. I think that outweighs the decision right now, but of course the two are related. Perceptions of safety translate into cost as well.

Senator **Fowler**. When was the last application for power plant construction in this country? Six or seven years ago?

Dr. **Blair**. No, long before that. I think it was 1972.

Mr. **Cooper**. 1976.

Senator **Fowler**. It seems like six or seven years ago. And you do not see any change in that?

Dr. **Blair**. No. I think the frontier for the nuclear power industry is a smaller scale modular approach, inherently safe designs. And there is currently an awful lot of research going on in that area. It is not clear how quickly the industry will be able to follow suit.

Throughout the world, the nuclear industry is very active in smaller scale modular design nuclear power plant concepts.

Senator **Fowler**. Are there any demonstration projects, for lack of a better name, on a smaller scale?

Dr. **Blair**. Not currently in the U.S.

Senator **Fowler**. Anywhere in the world? France or Sweden?

Dr. **Blair**. I do not believe there are any right now that are either under construction—there are a lot of design studies under way all around the world.

Senator **Fowler**. Dr. Blair, thank you very much for your time and energy.

Our last set of witnesses today are a panel, which we invite forward at this time: Mr. Frank Potter, President of the Renewable Energy Institute of Washington; Mr. Marc Ledbetter, the American Council for an Energy Efficient Economy, also located in Washington; Dr. Art Rosenfeld, Director of the Center of Building Science at the Lawrence Berkeley Laboratory in Berkeley, California.

I guess we will just take you in order of introduction. I ask for any resume of your thoughts and your presentation, and then we will have a discussion. Mr. Potter, do you want to begin?

STATEMENT OF FRANK M. POTTER, JR., PRESIDENT, RENEWABLE ENERGY INSTITUTE

Mr. **Potter**. Mr. Chairman, I am Frank Potter. I am President of the Renewable Energy Institute. I will, under instructions, be mercifully brief. You have an extended statement which I will ask be included in the record as if read. I would just like to summarize to some extent and to depart from it to some extent.

It is clear that the energy situation today is at best uncertain and dangerous. The energy security study that was just completed by the Department of Energy underscores that. We find ourselves in a situation where oil imports are rising, and we find ourselves in a situation where, for a number of reasons, there is an unwillingness on the part of government and industry to commit resources to new efforts to enrich our energy base.

They are a combination of events which together, I would submit, constitute what amounts to an energy crisis already today. The conventional wisdom is that there has to be a crisis for the organism to respond. I think that the rate of bank failures in the

Southeast, unemployment, the decline in our energy reserves, the growth in environmental problems that we already see, the increasingly uneven balance of trade, none of which are directly energy-caused but all of which are directly energy-related, in the aggregate constitute what I believe is in fact a crisis.

We have never really in this country defined what the government's role ought to be in trying to deal with future difficulties. Instead, we simply react on a case by case basis. In the energy area, our government's policies are essentially two:

One is the strategic petroleum reserve, which is very good for dealing with an energy interruption and no good for dealing with the long term problem. And the other is alternatives, and when you look to the government's plans for dealing with alternatives, essentially what you see is an empty book.

In the R&D world, the government is spending less, on the theory that the private sector would fit in and handle that part of the development work that needs to be done. But the private sector has not done that. We are not spending an amount on research, development, and demonstration which is equivalent to that of other countries.

Dr. Hubbard has already mentioned the case in Japan and Denmark, and they are very well documented problems. There is an enormous export market for renewable technologies, a market which private industry is longing for, but that it is simply unable to reach.

Senator FOWLER. Why?

Mr. POTTER. I think because it runs into that gap between what it wants to do and what it is able to do. We know the technology is developing, but for one reason or another we simply do not seem to be willing to make whatever effort is necessary, the kind of effort that has been made by other competitor countries.

It is certain to them that the market is going to expand. It is certain to all of us that the market is going to expand. But what are we doing about it? Not very much.

I think it is important to review our own energy position in the world, and the DOE energy security does, I think, a respectable job of defining where we stand now. What they do not do is to say, okay, now where do we go from here?

I think one of the things that is needed is to have a more careful analysis than has been done recently on where all of these alternative energy technologies stand. And I include conservation, which is probably one of the foremost of the renewable technologies.

If the energy sector does need help in these days of tight budgets, we need to look at ways to get the best value for that investment. Investments in a sound energy future are, it seems to me, absolutely essential.

There is a chart in my statement which shows the way that we have spent money on renewables R&D, and it is pretty stark. What we are doing, it seems to me, is we are burning our own seed corn in the interest of avoiding dealing with a difficult problem today. But the problem, of course, is that tomorrow does come.

I think what I also suggest in my statement is an alternative budget path which allows us to ramp up the amount of assistance in the federal sectors according to each technology to help us dig ourselves out of the pit that we have created for ourselves. And it may very well be that some additional effort needs to be done to assure that the R&D money that we are spending is being spent well.

I do not know whether the Energy Research Advisory Board presently responds to the Congress, to comment on the status of the DOE R&D program. If it does not, that is something you might think about. Congressional research of course—Congressional oversight is always useful and can be a riveting experience if you are on the wrong end of it.

Senator **Fowler**. It is always useful, except in matters of foreign policy.

Mr. **Potter**. The alternative, it seems to me, is that what we will do is lurch from crisis to crisis, and when we are persuaded that the problems are really difficult we will commit ourselves to a crash program. And Mr. Chairman, my experience working in and around the government has been that generally crash programs do exactly that.

Thank you.

[The prepared statement of Mr. Potter follows:]

United States Senate

Committee on Energy and Natural Resources
Subcommittee on Energy Research and Development

Testimony of

The Renewable Energy Institute

by

Frank M. Potter, Jr.
President

"The Current Status of Renewable Energy Technologies in our National Energy Policy"

Washington, D.C.
March 26, 1987

The Energy Situation in the Past

Until 1973, energy was generally perceived in this country to be a nonproblem. There were—there always are—exceptions, such as this Committee and its counterpart in the House. But no one seemed to pay much attention—cheap, apparently inexhaustible energy sources seemed to be guaranteed, and everyone believed them to be esstntial to our continued national economic growth. In 1973 energy got our attention. In 1979, the problems accelerated, and then in the past couple of years, we seem to have gone back to sleep.

Lessons that we ought to have learned from those difficult years might include the following:

- A diversified supply mix is important to a stable energy system
- There is a need to develop energy supply options that are less prone to significant fluctuations in price and supply
- The response in demand is considerably more affected by the price of energy than we had imagined to be the case

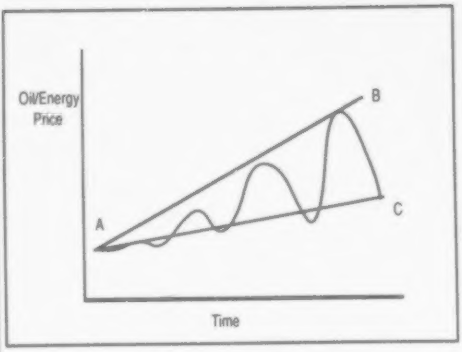
The Energy Situation Today

Energy prices (which generally fall into line with oil prices) are low, although increasing. Demand is down, in no small measure as a function of the events of the past ten years. The oil market is in a state of glut, and there is no lack of excess lifiting capacity for additional barrels of oil—although most of this is in the Persian Gulf. Oil import levels are up, and are certain to go up even further. At the same time, and very much related to this, oil production and exploration in this country are at record low levels.

The market for alternative energy sources is not deep today, although it is certainly growing. The electrical sector is in a state of some turmoil—the price of electricity is lagging oil prices, and independent power producers are playing an increasingly significant role in the supply of electrical energy to consumers in this country.

The Energy Situation in the Future

Oil prices are going to keep on going up, although not at a predictable rate. The question is not "whether," but "how much," and "how soon?" It seems more likely that they will be fluctuating, and this has important consequences for decisions in the private sector: a concern with the bottom line leads to decisions that are conservative, based on low projected prices.



For the individual or company that is making decisions about where to place emphasis, betting on the lower line—AC instead of AB—makes perfect sense. But the consequences of everyone making that decision are that the country remains vulnerable to the economic chaos that takes place whenever the price rises above that line—as it inevitably will.

Wiser men than I have commented that we seem to be unable to read the handwriting on the wall until our backs are against it. In fact, the handwriting is already there. The general feeling seems to be that it is not possible to mobilize any political will to act unless and until we are persuaded that there is a crisis—and since there is no energy crisis today, nothing need be done.

In fact, the reasoning seems persuasive that we are already in an energy crisis, albeit one that is as yet unidentified. Consider the following:

- Massive bank failures and unemployment in the Southwest
- Major declines in oil exploration and development everywhere
- A serious decline in our ability to compete in international markets, and even in our own markets for those commodities that other countries are producing today more efficiently and less expensively than we can
- A rise in environmental problems associated with energy (rising level of concern with CO_2 is one, but only one of these).

These are not all entirely energy-driven, but beyond any doubt there is a strong energy connection in all of these and that connection is making things worse, not better.

The Government's Role in Energy

If government has any role, beyond a bland (or blind) assumption that it has none at all, it is to anticipate coming problems and to create an environment in which developing or potential problems will become less serious. If we follow that thought to its logical conclusion, it seems inescapable that the government has a critical role in seeing that new energy technologies will be available, at acceptable or at least tolerable prices, at the time when they become necessary.

Today, this country has two systems to handle future energy problems. The first of these is short-term in nature. The Strategic Petroleum Reserve was set up several years ago to deal with what was then felt to be a serious problem: our short-term vulnerability to another energy interruption. It is now at the point where it can be of use in such an event. I am not here addressing the question of whether it should be larger than it is already.

But it is important to recognize that it is only a short-term response, designed to damp the violent price swings that created such economic havoc in 1973 and 1979. If it accomplishes these objectives—which it can only do if other industrialized countries act together—it buys a little time. And that is all that it can do. As an insurance policy, it is an important element of the solution to the puzzle.

The other part of the response system has to be alternatives to the status quo: energy systems that are less vulnerable to interruption. And that is where we are most seriously lacking in effort and options.

The renewables sector has suffered from the combined impact of the events: the decline in world oil prices and the increasing unwillingness of the government to put its money into a sustained and predictable effort to develop these resources. The loss of tax credits hurt, of course, although it did squeeze out some of the opportunists who saw in them a marvelous way to make hay while the sun was still shining. But the result has been to halt a fairly steady stream of progress in a direction which most believe to be correct and desirable, in the interests of a rational and affordable energy future.

Alternative Technologies

In the energy mix today, alternative technologies play an important, but not controlling role. Renewables currently provide some 10% of the known energy supply in this country, although this is far from a firm figure, and by its nature, cannot be. The importance of energy conservation is clear and its signficance for our future economic health is difficult to overstate. Other initiatives, like cogeneration and the rapid maturity of the concept of "least-cost" energy planning, are also on the increase.

What are we doing to nurture this growing element of the national economy? Not nearly enough.

Current R&D Priorities

Attached to this document is a table and some charts derived from it, itemizing appropriations for research and development for renewable sources of energy during the past ten years, and showing, for 1988, the sums requested by the Administration. No one, including the White House as far as we can tell, really *believes* those 1988 numbers, but that is, at least, where we begin.

This research budget needs to be examined, and I think that this review will demonstrate that the budget needs to be increased.

The Inspector General of the Department of Energy has concluded that the R&D programs within the Department lack any kind of coordination, program guidance or overarching policy review. That report, dated November 25, 1986, is still, as far as I know, correct. I am also prepared to believe, although I cannot claim personal knowledge of this, that these problems are currently under review. The point to be made is that the history of research is one that betrays a certain lack of clear goals—goals which we need very seriously today.

In an even more recent report, the General Accounting Office has reviewed the Department's energy research and development policy, to see whether it has applied the same criteria for all its programs, and to determine whether the R&D support from the private sector has been forthcoming at the levels that were expected. The Comptroller General concludes that the "long-term, high-risk, high-payoff" criteria, upon which the Administration's research agenda was based, have been more or less equally applied (except in the case of the civilian research program), but that the private sector has not put anything like the amount of effort that is necessary if we are to maintain a secure national economy—secure from crippling shortages and interruptions and secure as a base of continued economic growth in a vital area of the national and world economies.

Comparative R&D Commitments

In R&D and in absolute terms, the U.S. continues to maintain a substantial lead in the amount of money spent, allocating more than Japan, France, and Germany together. However, about half of all U.S. R&D is federally funded, with 2/3 of that dedicated to space and defense programs, with commercial impacts not generally a prime objective of those two programs. The U.S. lags behind Germany and Japan in civilian R&D expenditures. For example, as a percentage of Gross National Product, U.S. civilian R&D spending increased from 1.2% in 1961 to 1.8% in 1984. Japan and West Germany's civilian R&D spending, on the other hand, exploded. Japan's efforts increased from 1.4% to 2.5% and West Germany's rose from 1.1% to 2.4%. Taken as a measure of Gross Domestic Product, Japan increased 81%, West Germany 44%, and France 32% as opposed to the U.S.'s 15% between 1970 and 1979.

In absolute terms, U.S. civilian R&D spending exceeds every other country's because of the size of our GNP and GDP. Yet the strategies employed by other countries differ remarkably from ours. Japan, West Germany, and France have pursued aggressive commercialization strategies and are now in a position to export technologies and products created as a result of their R&D efforts The U.S. tends to pursue high-risk, experimental R&D and to look to industry for technological advances, a marked departure from post World War II days when aggressive U.S. government R&D efforts helped commercialize the aircraft and electronics industries. Coincidentally, those two industries were two of the U.S.'s leading exporters in 1985.

Like other U.S. business, U.S. renewable energy companies are struggling to keep up with foreign R&D efforts. After sponsoring several demonstration projects in many renewable technologies in the late 1970s and early 1980s, the U.S. Department of Energy now adheres to a high-risk R&D program, preferring to leave commercialization efforts to private industry. Furthermore, federal renewables R&D expenditures have diminished precipitiously. Since 1980, federal spending for renewables R&D has decreased by 76%, at a time when foreign government R&D spending, while smaller in absolute terms, has increased. In addition, other countries have pursued narrow, commercially-oriented paths than the U.S. Finally, foreign companies tend to spend more on R&D than U.S. companies, perhaps because of the perception in this country that the benefits from R&D are unpredictable and may give competitors a "free ride."

A specific example of these trends can be found in the U.S. federal government's photovoltaic, or PV, R&D budget. Since 1980, U.S. federal PV R&D spending has decreased 73%. Japan, this country's main PV competitor, has escalated its R&D spending at an annual rate of 25% and its R&D program is now considered to be equivalent to that of the U.S.. Moreover, Japan's PV industry invests three times more than the Japanese government.

In effect, the U.S. PV industry has been ceding an important competitive position to Japan. In 1980, the U.S. accounted for 91% of the world's PV production, and in 1985, Japan surpassed the U.S. in PV production.

A declining U.S. federal renewable energy budget is not, of course, the only reason for the U.S. PV industry's decline in international competitiveness. The strength of the U.S. dollar in 1985 made U.S. products considerably more expensive overseas and foreign competitor products correspondingly more inexpensive. The U.S. PV industry was also plagued by accusations of tax credit abuse that led to the spectacular demise of the concentrator power module market, hiding the gains the U.S. PV industry has made in stand-alone and remote installations. Furthermore, while a healthy R&D program is critical, other elements must be present for a successful export program, such as low-cost production and components, access to financing, and local contacts in foreign markets. Nonetheless, the contrasts in the approaches to government R&D programs and the commercialization of new technologies are striking.

Japan and Denmark have both aggressively pursued relatively narrow paths, concentrating on specific market and aspects of the technology, with the aim of exporting the eventual product, while the U.S. is now on a course of more general, high-risk R&D, with little thought given to export markets.

Alternative Technologies as Potential Markets

Despite the loss in competitive position, the U.S. is still a recognized leader in many renewable energy technologies. It has achieved this position largely through technical innovation and differentiation—offering a product that no else can match. In addition, U.S. renewable energy companies have acquired one-of-a-kind expertise in developing and financing renewable energy projects, due to federal renewable energy tax credits and other legislative incentives, such as the Public Utilities Regulatory Policies Act of 1978 (PURPA). As renewables continue their progress in becoming more reliable and economical, this experience may allow U.S. renewable energy companies to provide development services, components, and turnkey plants for domestic and international customers.

This course of action is not without risks: it may inevitably lead the U.S. to an important position in niche markets, such as supplying consulting and technical services but as not competitive in more lucrative markets. Unlike foreign competitors like Denmark and Japan, which have developed products from their R&D efforts, the U.S. can only offer technologies. Nor can the U.S. match foreign competitors in production costs, due to higher U.S. labor costs, higher component costs, and the increasing automation by foreign competitors.

Reversing the decline in U.S. competitiveness in renewables will take concerted and coordinated efforts on the part of both government and industry. Essentially, reforms can be identified as:

- Refurbishing U.S. federal renewable energy R&D programs
- Encouraging the export efforts of small, innovative but underfinanced U.S. companies
- Supporting efforts to develop renewable energy projects by organizations such as the World Bank
- Stimulating private sector efforts to become more competitive, e.g., automation, joint licensing, etc.

The Federal R&D Effort

As mentioned, the U.S. federal renewables R&D budget has been slashed and the emphasis changed to high-risk, more basic R&D, with commercialization being left to the private sector. As the budget has been reduced, stress has also been placed on cost-sharing between the federal government and the private sector. Consequently, the U.S. renewable energy industry is not only responsible for commercializing results of basic research but also for partially supporting basic government R&D efforts, further squeezing limited private R&D monies. A recent General Accounting Office report concluded that, with the exception of PV, private renewable energy R&D support has not kept up with federal cutbacks.

The cutbacks and change of direction in the U.S. federal renewable energy R&D program do little to improve U.S. international competitiveness in renewable energy, other than in developing and improving existing technologies. Many technologies are well understood technically and are close to being cost-effective. However, these technologies often lack operating experience, making them suspect in investors' eyes. A well-designed and implemented commercial demonstration program would give valuable performance data, prove the technology to investors, provide a needed market for U.S. renewable energy companies, and identify any additional technical or operating problems not previously detected. At least one government program—the Committee on Renewable Energy Commerce and Trade (CORECT)—is now pursuing such demonstrations, with the help of AID, the Departments of Energy and Commerce, and other institutions. CORECT was instrumental in developing the Bolivean PV projects and is participating in the Caribbean Basin Initative to stimulate business opportunities for U.S. renewable energy companies, especially those in biomass, solar heating and cooling, and solar thermal.

CORECT has also been credited with starting a relationship with the World Bank that resulted in the Bolivean PV project. These and relationships with institutions like the Organization of American States should be continued.

Helping Exports

The elimination of the U.S. residential renewable energy tax credits (all tax credits for wind), declining public interest due to low oil prices, and a national surplus of electrical capacity have all contributed to the woes of the U.S. renewable energy industry. To maintain business volume, U.S. renewable energy companies must increasingly turn to international markets. Unlike many other U.S. industries that are facing possibly irreversible declines in markets and competitiveness, the potential international market for renewable energy is enormous and generally unexploited. The U.S. Department of Commerce estimates that 15,000 MWe of renewable could be exported; as of 1983, about 3 MWe were actually exported. If this potential is realized, renewables could halt the steady decline in the U.S. balance of trade in power generating machinery.

Renewables offer a flexibility not always available in the case of other industries. Renewables can be high-tech, using sophisticated engineering and scientific principles or designs, and they can also be simple and low-tech, such as biogas digestors and direct-heat geothermal facilities. A large market exists in Lesser Developed Countries for low-tech applications, providing great market potential for the U.S. renewables industry.

In addition, the U.S. is the world leader or is at least still competitive in many renewable technologies, thanks in large part to research and development efforts by private industry and the U.S. Department of Energy. Furthermore, PURPA has provided U.S. renewable energy companies with valuable installation and operating experience, creating market opportunities in technical services and, in some cases, turnkey plants.

LDC countries represent an enormous market. As a result of growing economies and increasing industrialization, LDC energy demand has grown faster than that in the rest of the world. The World Bank projects that LDC energy demand will grow 4.5% annually from 1985-1995, as opposed to 2% per year between 1985-1990 and 1.5%/yr. thereafter for developed countries By 1995, LDCs are expected to account for 25% of all energy consumed, up from 20% in 1980

Today most LDCs depend heavily on imported oil. This dependence costs them dearly. In 1980, payments for net oil imports among 39 oil-importing LDCs accounted for more than half of their merchandise export earnings in 7 countries and between 25-50% of export earnings in 17 others. It also appears that the benefits of the recent drop in crude oil prices have not been all that valuable to LDCs. The Department of Commerce estimates that the cost of generating power using diesel generators powered by conventional fuels has remained essentially unchanged at $0.13-1.00/kWh.

International Financing

The countries that have the most market potential for renewables may be those that can least afford to buy renewable energy systems. The accumulation of foreign debt, a shortage of capital, the imposition of import restrictions, and the widespread economic recession because of decreasing exports have all acted to slow renewable energy market development in LDCs. Many are facing severe financial crises due to massive loans in the 1970s that must now be paid back to lending institutions and multi-lateral agencies. Latin America exported $45 billion in capital to foreign banks and corporations in 1984. To meet these debts, many LDCs are locked into a vicious cycle of maximizing exports and severely restricting imports, at a great cost to the U.S. LDCs buy more U.S. exports than Western Europe, Eastern Europe, Australia, New Zealand, the U.S.S.R, and China combined (World Policy, p. 170). Almost 40% of all U.S. manufacturing exports in 1981 were to LDCs. In that year, the U.S. had a trade surplus of $28.5 billion with LDCs; it became a deficit of $16.8 billion in 1985, a shift of $45.3 billion in 4 years.

U.S. renewable energy companies have been affected by other significant constraints. The cost of capital in the U.S., for example, can be twice as much as Japan's and other foreign competitors. This is due in part to foreign tax incentives and subsidies, but it probably also reflects differences in the rate of savings, interest rates, taxes, inflation rates, and monetary policy.

Increased Interest in Energy Alternatives

One of the biggest energy stories last year was the accident at Chernobyl. The accident accelerated public concern over the safety of nuclear power and the wisdom of depending heavily on it. France and Belgium now depend on nuclear power for well over 50% of their energy and there is a growing feeling that an energy diversification strategy ought to be pursued.

Of the renewable energy technologies, perhaps wind and PV will receive most of the initial boost from the Chernobyl accident. Some analysts are predicting widespread utilitization of wind and PV in Europe, especially if PV costs drop significantly. One analyst has suggested that 200,000 MWp of PV could be deployed in Europe by 2025, meeting 10% of Europe's electric needs, if costs are reduced and an ambitious PV mobilization strategy is implemented.

In wind, an Energy Directorate study for all European Economic Community countries except Spain and Portugal estimated the potential market at 50 GWe or, if utility plans are excluded, 8 GWe.

Some European governments are actively pursuing strategies to commercialize PV and/or wind. In West Germany, for instance, the government's Research and Technology Ministry will co-finance 2 MW of large-scale, grid-connected PV power plants with area utilities, consisting of three 30 kWe plants and a 1 MW facility. The total cost of the project is estimated to be $50 million. The West Germans are also reportedly increasing their wind budget to $450 million over several years. The United Kingdom considers wind to be its most promising renewable energy technology, and has devoted $28.5 million in R&D monies to wind since 1979, $8.55 million in the past year. According to some sources in the U.K., wind may provide 2000 MWe by 2025. The Danish government has devoted $63 million over the next five years to increase wind capacity from the current 5 MWe to 1,000 MWe by the year 2000.

Although the potential wind and PV market in Europe is great, realizing it may be difficult. Members of the EEC have tended to receive priority whenever another EEC member needs goods. For example, the EEC funded 16 PV demonstration facilities throughout Europe in the early 1980s, but made it clear that only systems with European-made components would be eligible for EEC funding. The EEC tends to take a dim view of non-member countries attempting to enter European markets, especially if an EEC member can supply the commodities. As an example, the EEC was recently requested by the chairman of the European Photovoltaic Industries Association to erect tariff barriers directed at the U.S. and Japanese PV industries. In addition, the renewables industries in Europe are well-established and formidable competitors. The Danish prowess in building and operating wind turbines is well-known, and Europeans were among the first to commercialize and use municipal solid waste facilities.

The U.S. renewable energy industry may nonetheless prove attractive for European markets because of the wide range of technologies that can be offered. In PV, for instance, the Europeans have concentrated almost exclusively on developing low-cost silicon materials and reducing the amount of silicon lost during wafer production. Silicon ribbon or sheet processing, now on the verge of commercialization in the U.S., will not be commercially introduced in Europe until at least 1990. In wind, the U.S. wind industry has jumped from small- to medium-sized machines at over 100 kWe in capacity. In 1986, the average turbine capacity installed in California was 106 kWe. European countries, though, are concentrating mostly on machines larger or smaller than 100 kWe, meaning that the U.S. wind industry may fill a niche in the market. West Germany and the U.K. are currently involved in testing multi-megawatt machines that the U.S. has largely abandoned as too costly and technically too difficult. Should these countries have the same experiences, they may be left without turbines to harvest their wind resources, and the U.S. may have a potentially exploitable market.

Changing times have forced many renewable energy companies to look overseas for new markets. Declining oil prices have caused many states to lower utility power purchase rates under PURPA, referred to as avoided cost payments. Renewable energy tax credits were only partially renewed after their expiration in 1985, excluding residential and all wind systems. Public interest in energy issues has gradually waned, perhaps to the point of disappearance.

The international market for renewables has enormous potential, but confronts many barriers as well. Renewable energy companies face serious obstacles in obtaining commercial capital, and at the same time the industry generates little interest among U.S. export trading and export managing companies because of their perceptions that the market is too small or too difficult to develop. Consequently, the U.S. renewable energy industry generally does not have access to a marketing network, unlike foreign competitors with ties to former colonies or with long-established trading partners.

A need exists to educate policymakers and potential customers on renewable energy. The major portion of the cost of a renewable energy system lies, in most cases,in its capital costs; operating costs can be much lower than conventional fuel systems in many cases, due to little or no fuel costs and minimal operations and maintenance costs. Examining the cost of an energy system over its operating life, sometimes called "life-cycle costing," has not gained acceptance among many policymakers, many of whom prefer to compare the up-front capital costs of different energy systems. This is aggravated by a shortage of up-to-date cost and performance data on renewables.

Conclusions

A number of conclusions can reasonably be drawn from this situation—some of them critically important to our future.

We have an energy problem, and we know that problem is going to get worse, not better.

Other energy sectors are already looking for significant help from government, in the form of tax or regulatory relief, and other subsidies in one form or another.

The oil industry is looking for billions of dollars of assistance in form of tax relief and tariffs to help them rebuild a shattered system. Keep in mind that virtually no one, that we are aware of, is claiming that there are new super-giant fields to be found in this country. This is another way of saying that what they want is help in speeding up the rate at which they drain our own reserves. Whether or not this makes good policy sense is something to be considered in another context. But clearly they need, and no doubt deserve, help in some form.

The coal industry has big problems as well. Coal is abundant in this country—it is also difficult, expensive and dangerous to extract, and some of its side-effects, in the form of emissions, pose enormous problems for regions of this country. CO_2, which is produced in very large quantities from coal, creates a threat to the entire world—not only to those living in the coastal cities that may be inundated in the future.

Some members of the electric utility industry consider that the Public Utilities Regulatory Policy Act has created a whole raft of problems for them, and that independent power producers are unfairly advantaged. They are asking the Federal Energy Regulatory Commission to review PURPA, to see how those regulations should be changed.

The nuclear industry is already receiving substantial R&D assistance from the federal government. In terms of what it is producing today, to say nothing of what it is likely to be producing in the future, and comparing it to what renewable fuels are and will be producing, it appears that its relative advantage is on the order to 100 to 1. It is hard for me to believe that this ratio bears any resemblance to the relative value of renewable energy sources in the near, mid or long term.

All this is not to say that assisting energy development is not desirable. What I am saying is that we ought to do those things today that will give us the widest reasonable range of options for the future. Clearly the renewable energy sources, which have significantly less problems associated with them than do all the others, deserve to be treated no less fairly than their competitors. If anything, given their potential, they ought to receive more, not less, help.

A Realistic Renewables R&D Budget

The numbers indicate that the renewable part of the energy mix has gotten very short shrift in the past few years. While I certainly understand that times are hard and budgets are tight, I have to conclude that things are out of balance and that it can and must be done better.

The renewables indutsry is a young one, without a large and deep pocket into which to dig for R&D dollars. Its potential is great, both in terms of supplying badly needed energy supplies at a time when we will surely need them, and in doing so in a way that is less environmentally stressful than any of the alternatives.

The government's theory— that the private sector should be encouraged to do much of this work itself,— is logically sound. If the work were being done, then there would be no need for further government intervention. But the cold, hard fact is that it is not being done and that we will otherwise pay a stiff price for this inattention at some point in the future when it will be called forcefully to our attention. The likely result of this kind of scenario is that the government will eventually be called upon to launch a crash program, and such a program will probably do what programs of this type frequently do: it will crash. I doubt that you need examples.

REI has talked to representatives of the various renewable energies technologies, and has come up with what we believe would be a reasonable starting point in developing abudget for a longer-term research agenda. The numbers in this agenda represent an educated guess as to the amount of funds that could be responsibly and effectively put to use. Throwing money at a problem makes it disappear no more quickly than trying to starve it by ignoring it.

Industry spokesmen have come up with number which they feel would salvage at least some of the gains that have been made in the past. Their estimates are presented in the attached Table, identified as "Renewables Budget, 1987-1991." Such a budget would stop the hemorrhage in renewables development that is beginning to take place. It would not begin the effective rebuilding of renewables technologies that must take place if we are to begin the painful process of regaining the ground that has been lost in the past years. We have indicated a set of estimates that would begin this process as "Preferred" and have continued that trend in proposed numbers for the out-years, 1989-1991.

On the same page is a schematic chart, showing the path that new technologies typically follow on the way to commercialization. We have gone through the stage of "Grand Predictions" for all of the renewable technologies, have run into many of the problems and are now climbing the curve toward full market penetration. That process can and should be shortened by appropriate government intervention, not to second-guess the market—a process at which it can be spectacularly inept—but to help it identify those technologies that will best fit the needs of Americans for reliable, safe and affordable energy in the years to come.

Solar Buildings

Any technical approach that increases the energy efficiency of the nation's building stocks deserves significant federal government attention. Although solar technologies for meeting building energy needs have already entered the market place, many opportunities to increase efficiency and lower costs remain Furthermore, development of such technologies as solar cooling have been stalled by severe cutbacks in this program area. While passive solar design often appears simple, complex physical and thermodynamic priniciples are involved and the building sector has not exactly embraced this technology with open arms. More work is required, in technical and in non-technical areas involving market and institutional barriers. DOE's focus on material and component research and design analysis needs to be supplemented by an active program to stimulate a more rapid penetration of the market for these technologies. Educational programs, financially oriented assistance (e.g. FHA qualifications for solar, low-interest loans for lower income homeowners, etc.) and technology transfer to industry are all important to the goal of overcoming short-term investment outlooks of building owners and the low first-cost orientation of the construction industry.

Photovoltaics

In a little more than a decade, concentrated government and industry research and development have produced substantial gains in photovoltaic technology [illegible] worldwide industry now exists for speciality applications. The larger potential of this energy source will not be realized, however, without continued large investments by government, utilities, and industry. These investments remain risky because scale-up of manufacturing facilities is difficult to justify when no "clear winner" technology has emerged. R&D gains, coupled with economies of scale from increased manufacturing, will help the ultimate potential of these technologies to be reached. The federal government has played, and must continue to play, a critical role by helping U.S. PV companies identify near-term markets and supporting purchases for government use that will expand U.S. industry production capacity. If we wait for the longer-range R&D focus of DOE to pay off, we will certainly lose our technological edge to foreign competitors—whose govermnments are increasing their PV funding support—that establish themselves in early markets and increase R&D expenditure through industry earnings from commercial sales.

Solar Thermal

Increased federal support for solar thermal R&D will ensure that this technical option for producing electricity and industrial process heat will be available in the mid-1990s. The last decade of research has proved the technical merits of several systems. The research still required will refine existing technologies, lower their costs, and develop breakthroughs in components that promise even further cost reductions. For example, a [illegible] utility-manufacturer-government project is now [illegible] choices on the design of the next generation central receiver plant to follow the highly successful Solar One pilot experiment. Increased funding will be required from government, ratepayers and industry in order to demonstrate this new, technology in a commercial configuration. Dispersed solar thermal technologies also show great promise, and new generations of innovative concentrators, heat engines and exploration of advanced manufacturing techniques using highly concentrated solar flux deserve increased R&D funding..

Biomass Energy

Energy from biomass and waste is already the largest renewable energy contributor to U.S. energy supply. The need for increased R&D arises in two ways. Commercial technologies already in place will benefit from additional R&D to increase their efficiencies and lower their costs. Meanwhile new technologies, already in the pipeline, that have tremendous potential in the future should be developed and commercialized at a faster pace. Budget cuts in the recent past have dropped the program to a level below critical mass for these technologies and have endangered the regional program that Congress created to facilitate technology transfer. As it is now operated, the program does not permit investigation of new ideas and concepts. Higher levels of funding are needed to restore a core R&D program to a healthier state. Furthermore, a more realistic level of government support would include funds to address those market penetration barriers that are not technically driven. This increase in support can easily be justified because the nation will need new sources of liquid, gaseous and solid fuels.

Wind

The development of modern wind energy technology for producing bulk electricity has been a major success for industry and DOE. From an undeveloped resource in the late 1970s, wind power already represents one percent of electric capacity for a west coast utility. It has the potential to contribute as much energy as hydropower is contributing to national energy supply today. The U.S. wind industry, however, has been hit doubly hard. Expiration of tax incentives and the federal R&D program cuts have meant that wind energy has lost nearly 90 percent of the support from the government. Meanwhile, industry has developed systems with installed capacity costs that are well below clean-coal plants. They are already competitive in California. The program needs to be restored on two levels. Government should increase its own purchases of wind technology and provide support for overseas purchases to increase the market for existing technology. In parallel, a focused R&D program needs to address many technical needs to improve the competitive position of the U.S. wind industry. These include the need for better design methodologies, better understanding of power interfacing requirements of utilities, work on advanced airfoils and variable speed generators, and continued research to identify key factors contributing to wind turbine stress and fatigue.

Ocean Energy Resources

The United States continues to develop technology for tapping thermal energy resources in the ocean. Other countries have made significant gains in tidal and wave technologies. The U.S. program should sustain its efforts in the ocean thermal energy conversion field, expand cooperation with other countries, and begin to assess critically the progress being made overseas with other technologies.

Geothermal Energy

Geothermal technology encompasses a variety of resources and technologies to convert this resource to useful energy. Direct-use geothermal and hydrothermal conversion technologies are closest to commercialization, and the industry proposes phasing down—that is not a typographical error— federal R&D funding, beginning in the early 1990s. Geopressured, hot dry rock and magma resource development is further from the marketplace and will require consistent government spending to maintain appropriate levels of industry activity. Successful exploitation of these resource options will greatly increase the potential useful energy derived from geothermal technologies on a national scale. The U.S. industry has the expertise to maintain its worldwide leadership role in geothermal energy technology. A continued commitment by the U.S. government will give other countries with geothermal potential, many of which are LDCs, the confidence to develop their own resources, using U.S. industry for support.

Small Hyrdopower

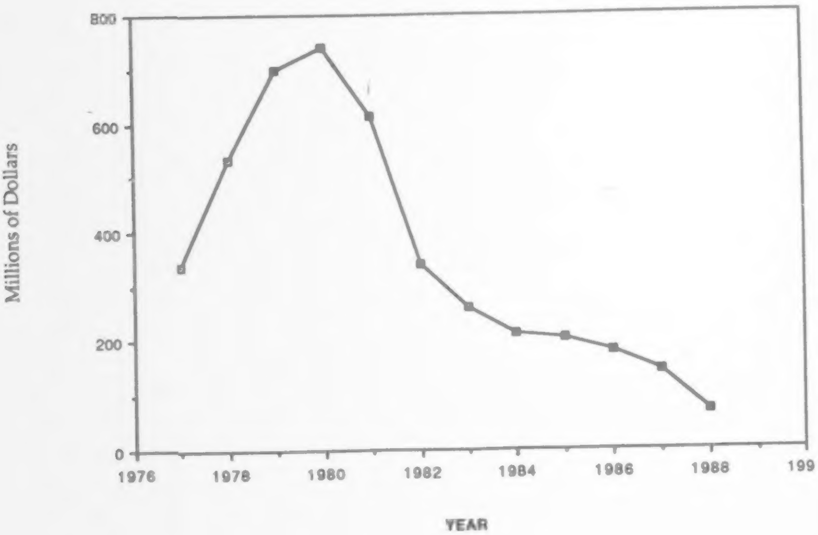
The United States still possesses significant hydropower resources that are either untapped, or could be restored. Some of this development has already occurred, thanks in large part to encouragement of independent power production by the Public Utility Regulatory Policies Act (PURPA). The federal government could step up the pace of development through applied R&D to increase system efficiencies and through development of more sophisticated resource assessment techniques and environmental control technologies. The program should also increase the level of coordination with electric utilities and third-party project developers.

Renewables Budget 1977-1988 ($Million)

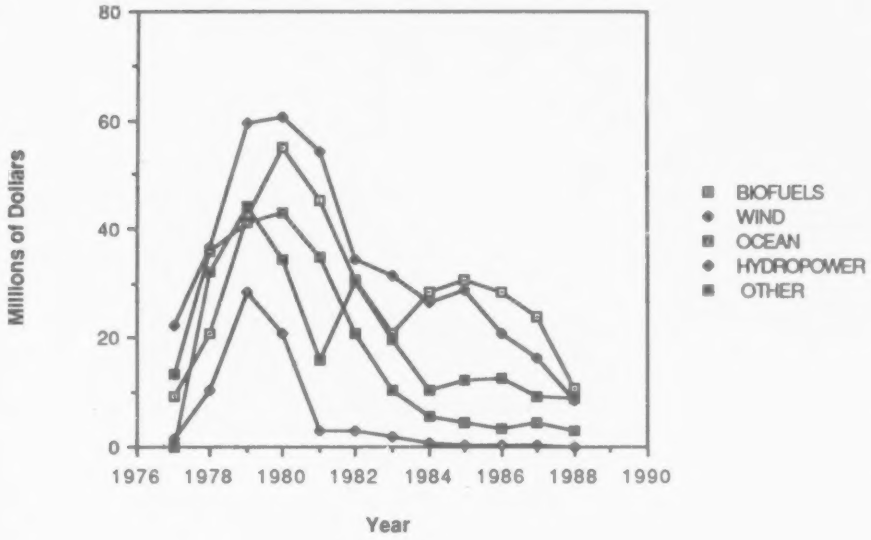
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Solar Bldgs.	113.6	121.8	89.7	84.8	68.6	22.1	11.6	16.4	9.7	9.5	5.9	5.4
Photovoltaics	54.8	63.5	120	150	133.2	74	58	50.4	56.6	44.8	40.4	20.4
Solar Thermal	69.5	104.1	117.2	143.2	120	55.9	49.5	43.8	36.2	28.4	22.9	14.1
Biofuels	9.5	21.1	42.4	55	45.2	30.5	21	28.4	30.8	28.4	24	10.7
Wind	22.4	36.7	59.5	60.5	54.2	34.4	31.4	26.5	28.6	20.8	16.6	8.5
Ocean	13.6	36	41.1	43	34.6	20.8	10.5	5.5	4.4	3.5	4.5	3
Geothermal	53	107.9	157.9	149.2	137.5	69.9	57.6	30.4	25.2	31.8	20.9	15.9
Hydropower	1.6	10.4	28.4	20.9	3.1	3	2	0.7	0.5	0.4	0.5	
Other	0	32	44.2	34.5	15.9	30.4	19.8	10.5	12.2	12.6	9.2	9.1
TOTAL*	338	533.5	700.4	741.1	612.3	341	261.4	212.6	203.4	190.2	144.9	87.1**

* = Actual
** = DoE Request

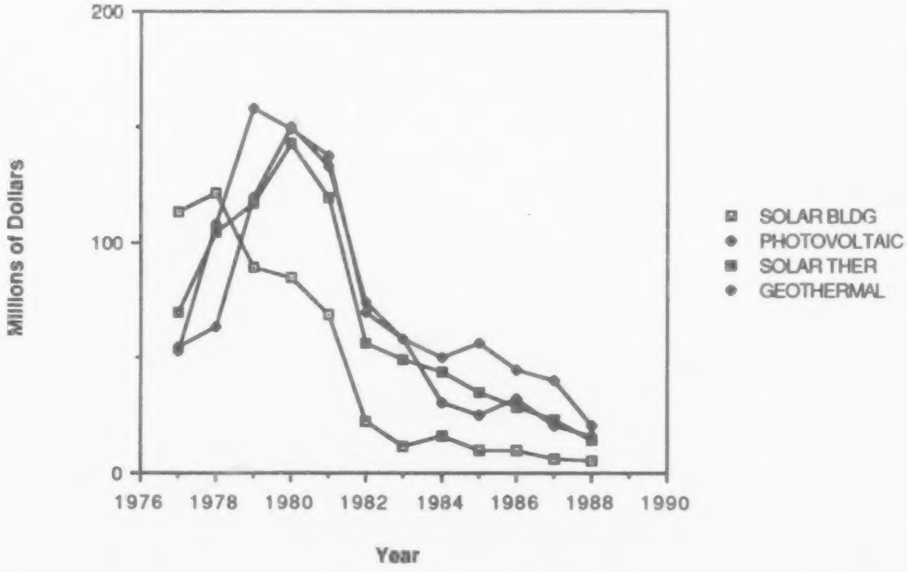
Total Renewable Budget 1977-88



Renewable Budget (B) 1977-1988



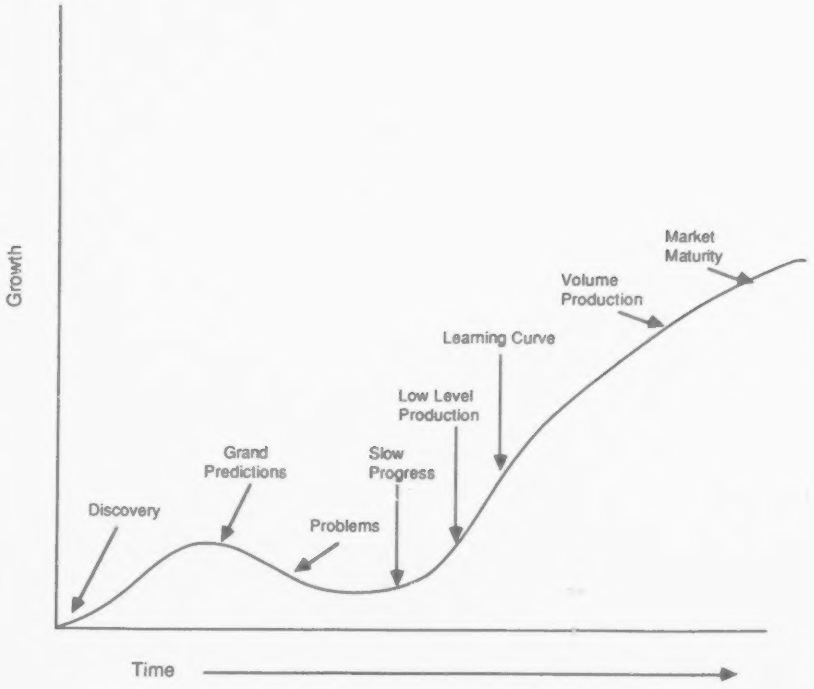
Renewable Budget (A) 1977-1988



Renewables Budget 1987-1991 ($Million)

	1987	1988	Industry	Preferred	1989	1990	1991
Solar Bldgs.	5.9	5.4	7.4	10	12.5	15	18
Photovoltaics	40.4	20.4	50	60	75	90	90
Solar Thermal	22.9	14.1	28.6	36	75	82	79
Biofuels	24	10.7	32.1	38	58	90	90
Wind	16.6	8.5	16.75	23	35	100	100
Ocean	4.5	3	4.5	5	5	5	5
Geothermal	20.9	15.9	18.2	18.2	19	19	12
Hydropower	0.5	0	0.5	1	1	1	1
Other	9.2	9.1	9.2	12	15	15	15
TOTAL	144.9†	87.1Δ	167.25	203.2	295.5	417	410

† = Estimated
Δ = DoE Request


Growth
Discovery
Grand Predictions
Problems
Slow Progress
Low Level Production
Learning Curve
Volume Production
Market Maturity
Time

Senator **Fowler**. Thank you very much, Mr. Potter.

Mr. Ledbetter, welcome.

Mr. **Ledbetter**. I do not normally ask to go last. As a matter of fact, I usually complain about it. But some of my comments are best said after a certain context is laid out, and Dr. Rosenfeld can lay out that context. So for this one time, I am going to ask that I go last.

Senator **Fowler**. Do you agree with that?

Dr. **Rosenfeld**. Absolutely. We have got our two-man act here and it would be better if I go first, if that is all right.

Senator **Fowler**. We would be delighted.

STATEMENT OF DR. ARTHUR H. ROSENFELD, DIRECTOR, CENTER FOR BUILDING SCIENCE, APPLIED SCIENCE DIVISION, LAWRENCE BERKELEY LABORATORY

Dr. **Rosenfeld**. What I would like to do, Mr. Chairman, is, you have seen my testimony and there are seven or eight figures and a couple tables, and what I thought I would do if I have ten minutes is just to spend one minute talking about the moral from each of those. And I do not know whether you have it in front of you. If I can assume you have it in front of you, then it will make a little more sense.

The first point I want to make with the first figure is how unbelievably well conservation has worked, the moral being if you have a real winner which is three or four times cheaper than existing fuel or electricity and maybe 100 times cheaper than the existing renewables, then you ought to put your first bet on that.

Obviously, I am not saying that we should not do research on renewables. We just heard hours of testimony about why we need that. But in terms of living through the next 20 years, I think everybody in this room would agree that it is conservation which has worked beyond our wildest expectations.

And I wanted you to look at that for a minute. In this first figure, which is for the United States, there are two plots superimposed, and that is why I wanted to take a minute, because there are so many lines there I have to tell the Committee about each.

If you look at the squares, they represent all of energy, primary energy, that is oil, coal, electricity. And there is a dot at 1973, where I have combined the open circles—or the open squares and the black squares. And then if you backcast from there, taking the old rule that, when nobody paid any attention to energy we used it at a constant efficiency, then energy used to be proportional to GNP.

And you can see as you go back to 1965 that worked pretty well. So while the economists in 1973 seemed to feel that energy was connected with GNP, then the price went up and it became interesting to improve our efficiency.

If we were stuck at 1973 efficiencies, we would now be up to that enormous peak with the square at 100 quads, and we would be paying $600 billion a year for energy. As a matter of fact, we have improved our efficiency. We have stayed at 73 quads. We are only—"only"—paying $440 billion a year for energy. We have saved $150 billion a year, barely trying.

So we have a very flabby society. If we keep on doing R&D and pushing it into society, we can accelerate that process. So we have plugged, out of a $350 billion leak, we have plugged $150 billion a year already. That is pretty good.

Now, what are the implications on oil, which is connected with the energy security issue, which Mr. Potter just mentioned? The symbols are oil and gas, because we can interchange them in our society. For example, utilities burn one or the other on different days depending on which is cheaper.

If we had stuck at constant efficiency, we would be up to 70 quads of oil and gas alone. In fact, we have improved our efficiency very easily. We are down to 45 quads. We have saved the difference, which in units of quads people forget, but if I give it to you in units of OPEC's maybe you will remember.

And it is 0.8 OPEC's. That is, in this country by getting our act together so far we have saved 80 percent of last year's production by OPEC, which is incidentally 100 percent of their present production because they just cut their production.

Think what the price of oil would be if there were another OPEC worth of imports in the world. Well, you say, no, it would not be imports; we would just go drill some more. Well, that is not true.

On the bottom line you see U.S. oil and gas production and you see it sagging inevitably because we are running out of the stuff. There is no way we could have made enough oil and gas in this country to offset that 0.8 OPEC's. So it would have come out of oil imports.

Now, to rub this point home a little further, if you will turn to figure 1B, which is on the next page, I redid the same thing in the same format for the total of OECD. That is North America, Europe, Japan, Australia, Asia. The picture in savings in total energy is about the same. The savings for OPEC is $250 billion a year. That is pretty good.

And if you look at the savings in oil imports, you will see—oil and gas, you will see that we are now up to 1.5 OPEC's. And I leave you to consider what the price of oil in the international market would be today if, in addition to OPEC's regular production, there was a demand for another one and a half OPEC's.

The price of oil would be $100 a barrel. We would all be in the deep stuff that we are going to be in, in 10 or 15 years anyway.

Somehow or other, by going in for efficiency, we have got ourselves a window, which might last as long as ten years. And what are we doing with that window? We are backsliding. Conservation R&D budgets are going down. Solar R&D budgets are going down. The Administration is backtracking on automobile miles per gallon standards, and so forth and so on.

And our kids are simply going to consider us as a generation of vipers, because we are using up all the resources that should be saved for our kids and our grandchildren.

So that is figure 2. Figure 3 is easy to get over, and that is, if you look at figure 1 where you see U.S. oil and gas production sort of only declining slowly, you get a wrong feeling of security because, look, it has only declined ten percent in the last ten years. Of course, to keep it up there we spent a quarter of a trillion dollars on exploration. But that was uneconomic.

Now, if you look on a larger historical basis and you look on the curve that I have got in figure 2, which runs from 1900 to the year 2040, you see the famous pimple of M. King Hubbard, and you see actual current production superimposed on that as the solid line. And you see how we are starting inexorably down that steep slope.

And the authors of this particular publication estimate that it is in the year 2000 that we will be spending more than one barrel to discover a barrel, at which case we give up, of course. Well, the year 2000 in terms of people who have children and grandchildren just is not that damn far off.

And if you think about building sloppy buildings which we are putting up today, including federal buildings, the buildings are going to be in middle age at the time that our kids are going to hate us for putting them up, and they are going to have to retrofit them at great expense because we put them up, for example, without thermal storage, although the right thing to do is to put in thermal storage.

So, arguments for R&D.

Senator FOWLER. Where on this curve do we reach the point where we are spending a barrel, using a barrel to find a barrel?

Dr. ROSENFELD. About the year 2000. So basically, the United States gives up about the year 2000. The Russians give up about the year 2015. That is going to be a real paroxysm, because they have not learned anything about conservation.

The British North Sea runs out around 2020, and after that all that is left is China and OPEC. So if you think the Chinese are pretty friendly, well, they can supply a million barrels a day for a few more years, and after that it is all OPEC, and you can figure out the price of oil and gas.

All right. So we are headed for disaster. Now, as to the savings again, go back to figure 3. Figure 3 is the same side of the story that I showed you in consumption on figure 1, but instead it is just in terms of capital investment we have avoided.

This is capital investment yearly by the electric utility industry. And we had a great big giant spending spree in the years 1979 to 1984, roughly, $50 billion a year—bad planning for power plants we really do not need yet. Now we are getting our act together.

This is not my figures. This is just copied from Electric World. They say we will go down to $17 billion a year. Then, according to Electric World, we will get back to normal and we will start growing again.

The real challenge for efficiency is to see whether we can avoid that second wave. If we can avoid going to $40 billion again a year and stick at 10 or 15, we will save $20 or $30 billion a year.

That is 10 or 15 percent of our total annual capital formation, so that instead of having to go into energy supply of this sort we can go into airframe manufacture or computer manufacture or automobile manufacture, all the things we can sell on the open market.

The trouble with energy is it is essential when you need it, but excess energy is of no economic value whatsoever. You cannot sell it to the Japanese.

So that is figure 3. It says we have made enormous progress; we saved ten percent of our total capital formation at very little expense.

Figure 4 puts all this into context looking in the future. I have made a point. I have said it and I want to say it again: We saved about $150 billion a year so far. How much further can we carry this process? What is economic?

Well, one way to look at that is to ask whether, say by the year 2000 or 2015, 2010, we could be today as efficient in the use—we could be as efficient in the use of energy as the Japanese are today. That does not seem to be so hard to figure out.

And for efficient I do not just mean efficiency per capita, because maybe the Japanese have smaller houses or smaller cars. I mean efficiency per dollar of GNP. Well, we today in the United States, although we have made progress, are still spending 11.2 percent of our GNP on energy, because we still have a lot of incandescent lamps, and we still have pretty big cars, and we do not insulate industrial products very well, and so on.

The Japanese are down to 6 percent of their GNP in energy. The French are at 7. All our competitors are better than we are. So they, the Japanese, have a 5 percent economic edge on everything they sell just because the energy costs are less.

Well, if we were as efficient as the Japanese, instead of spending $440 billion today, we would be spending $220 billion. It seems to say there is another couple of hundred billion dollars a year leak out there to plug, and that we ought to do that before we start draining America for more oil.

And you can plug that leak for numbers like five dollars a barrel, and everybody knows you cannot buy a hell of a lot of imported oil for five dollars a barrel. So put in this context, then, you can think of a left-hand bar labeled in billions of dollars per year as a sort of giant holding tank for a year's energy, and we pour—right now we pour $440 billion of primary energy into the top. We get out about $220 billion of real optimum resources, and a leak of $220 billion.

And to plug that leak some more we need to continue R&D, but we are not doing it. The federal government wants to cut our R&D budget to half next year.

Okay, that is the end of the numbers. I will not give you a lot more numbers for a minute or so. The next figure is simply a set of pictures of improvements in electricity which we have developed at LBL. The lower two pictures are ballasts for fluorescent lamps like you see in every commercial building.

The reason I give this picture is to show how some new industries are being formed. The first picture is dated 1987. It is a prototype ballast which cost then ERDA something like $200,000. It was a great success. It is now in production. The 1986 version, looking about the same, is shown to its right.

Those ballasts will go into production because they are so efficient. They will take over the market. They will save the need for about 15 power plants in the United States alone. They save energy for two cents a kilowatt-hour. New power plants are ten cents a kilowatt-hour. This is four times cheaper. That is a typical sort of return on an efficiency investment.

And we know how to continue that a lot. We have lots more tricks up our sleeves, but R&D budgets are being cut.

Some more industries that came out of that. The little circle above that ballast is the compact version of the whole thing, same thing, which was done by the Philips company using the LBL technology, which then fits in the little lamp at the left, which is the famous 18 watt Philips SL-18 compact fluorescent bulb.

That's a fluorescent bulb which for 18 watts gives you the same light as a 75 watt incandescent bulb. During its lifetime, which is about a year, that bulb will save $35 worth of electricity at average prices, and 400 pounds of coal. So there's a sort of nice David and Goliath story.

But the group which is doing that laid off five people. I laid off five people this year, although there are lots more things we can do in that direction.

And just to show that the competition is pretty tight, to the left of that you see the Japanese competition, and to the left of that you see the American product, General Electric, which is in the compact fluorescent business.

That is another way to save about 30 power plants in the next few years.

The next one does not even have a picture, but I wanted to wave it around.

Senator **Fowler**. Let me interrupt you there.

Dr. **Rosenfeld**. Yes, I like to be interrupted.

Senator **Fowler**. Why? [Laughter.]

You obviously know how to do these—why do cutbacks in research and development affect these products?

Dr. **Rosenfeld**. It will not affect the things that are done. But we know how to save an equal number of power plants with more technological developments.

Senator **Fowler**. I understand that. But what is to keep these from being marketed?

Dr. **Rosenfeld**. Oh, no, these are being marketed. They are done, they are out of our hands. The government is not spending a penny more on them.

But we know how to make a ten percent improvement in fluorescent lamps by loading them, for example, with a different mixture of mercury isotopes from what goes in there now. Well now, ten percent on a fluorescent lamp may not seem a lot, until you realize that there are 100 power plants in the United States that do not do anything except run lighting. So ten percent is ten power plants.

Senator **Fowler**. I understand that. How many of these ballasts do you have to sell in this country to equal the output of ten of those power plants?

Dr. **Rosenfeld**. These ballasts, because they are cheaper life cycle than regular ballasts, they will take over the whole market. I am assuming—I mean, if you ask General Electric or Westinghouse or whatever, they will tell you these ballasts will take over the market.

Senator **Fowler**. When?

Dr. **Rosenfeld**. Oh, they will saturate the market by 1990, 1995. And then of course there is another ten years for them to be installed in buildings like this, because ballasts are only replaced every ten years. So the full impact of these ballasts will come in around the turn of the century.

So there seems to be some confusion. There are some projects which we have done, we know are a success. And then the question is, can we keep on with this good show? And the answer is, of course, we can if R&D budgets are continued, and we cannot if our guys are pumping gasoline and driving taxi cabs.

Did I really answer your question?

Senator **Fowler**. Yes.

Dr. **Rosenfeld**. Okay.

Senator **Fowler**. I do not know whether you answered it, but I understood the answer.

Dr. **Rosenfeld**. All right.

The next thing I was going to wave around is this. Now, this looks like an ordinary piece of glass. It is transparent to visible, but it is a reflector to infrared. So if you were looking at this in infrared light, it would be a reflector, like a thermos bottle is a reflector.

Now, we all know that you can keep your soup hot for a long time in a thermos bottle. On the other hand, if I tried to put a silver mirror on these windows that would not sell very well, because people like to see through windows. So you want to find a reflector for infrared, heat, but let the light through.

Well, there is a product. We engineered this at Lawrence Berkeley Lab. It is also going to take over the market. It is a great success. It costs about a dollar a square foot. It will take over the market by about 1995, and then another 20 years to replace all the windows and by the year 2005 this will be sort of commonplace.

And by that time it will be saving about one-third of the total output of the Alaska pipeline. So there is another David and Goliath story. But the group whose——

Senator **Fowler**. There is nothing wrong with your analysis.

Dr. **Rosenfeld**. Thank you.

But the group which produces this sort of thing—and we have lots more tricks—we are laying off people. These things have a thousand to one return to society, but somehow or other the federal government says: Oh, the market will take care of all of this, and so we do not have to do any further research.

The problem is the market is very, very fragmented. The buildings industry is really a non-industry. It does not have research labs. It has thousands of contractors and very little ability to do research. And so R&D takes a long time.

I am sure by the year 2020 all these things will get developed by industry, but the market will have been taken over by the Japanese and the Europeans first, because, as Potter and other people will tell you, their governments help them do this sort of thing.

Senator **Fowler**. We have to leave some time for your colleague, Mr. Ledbetter.

Dr. **Rosenfeld**. I am at my last figure. The next section in my testimony of which figure 6 is a part is an attempt to defend some softer things. That is I can say this is a third of Alaska. When it comes to computer programs, for example, the building industry has been completely revolutionized since prices went up. A building today uses a third as much energy per square foot as the average stock out there because it has more efficient windows, for example, and more efficient lighting, and it uses about a fifth as much as your typical old glass 1970 vintage building.

Now to do that you need computer programs. That is, we have revolutionized most of what we make today. Cars have doubled their mileage per gallon, but it is done with computer programs. Airplanes have done better. Airplanes are now getting about 40 percent as much fuel per passenager mile as the pre-OPEC airplanes, but it takes a lot computer programs.

We did the computer programs for buildings at LBL, and that has been an enormous payoff. We have now decided that the thing to do is to redo them on an international basis to make buildings even better. We started the program, budgets are being cut, the leadership is gradually moving to the British, the Americans don't want to authorize anything beyond one year. The British think it is important, so they have authorized a 60 man-year effort. Again, we are losing leadership in this nice field. We are still hanging on there with our teeth, and we still have four people left. Compared to real management we are slowly going down the drain.

The last one is the least cost utility project, which was authorized by the Congress. It was the only new initiative we've had in five or six years. It was a $1 million per year authorization. There again we have run into trouble because the main reason for the least cost utility project was to take very valuable data bases which are all smeared all over the place—LBL has one, EPRI has one, Gas Research Institute has one—they are more or less contradictory and incomplete. They should be merged and brought into the public domain, but that is a five-year project and somehow or other the Department of Energy doesn't fund five-year projects anymore. They want instant gratification. So these projects are going very slowly and need more support.

The last remark introduces Mark Ledbetter. We have had almost no new initiatives. We've had one serious new initiative in the last few years, and that brings us to the whole question of the conservation budget and to new initiatives, and that is the lead-in.

Senator FOWLER. Thank you very much, Dr. Rosenfeld.

[The prepared statement of Dr. Rosenfeld follows:]

Energy-Efficient Buildings: The Case for R&D

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Testimony for Hearing on Conservation and Renewables
Subcommittee on Energy Research and Development
Senate Committee on Energy and Natural Resources

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Introduction

Good afternoon. I am Arthur H. Rosenfeld, Director, Center for Building Science, Lawrence Berkeley Laboratory, and Professor of Physics, University of California, Berkeley.

Since FY 1980, the funding for Conservation R&D has dropped from $344 M to $162 M, despite the fact that annual savings from past conservation investments have now mounted to $150 B/year, roughly 1000 times the current R&D budget.

I am here to defend conservation in general, but most of my examples will be focussed on buildings, the sector I know best and one that accounts for 36% of the annual US energy bill.

I. Conservation Has Worked Beyond Our Wildest Expectations

I-A. Savings in the US and within OECD

I introduce Fig. 1 to show the remarkable savings wrought by improving our energy efficiency since 1973, and particularly since the second and most serious energy shock in 1979.

Before 1973, energy prices were low and there was little interest in improving our efficiency, so it was conventional wisdom that energy use would grow at least as fast as GNP. On Figs. 1a (for the US) and 1b (for OECD), the solid squares are actual use, and the open squares are backcast and forecast from 1973 assuming "frozen efficiency" so that energy use must be proportional to GNP. We see that the US has made 33% improvements in efficiency, saving ourselves $150 B/year, but leaving us still paying $440 B/year.

In the figures, the circles represent oil plus natural gas, which are partially interchangeable in our economy since many boilers switch from one fuel to the other depending on the price. Here the story is even more remarkable. Despite a 33% growth in our GNP, our oil+gas use has declined even faster than our (also declining) domestic production of fossil fuels (indicated by diamonds). Compared to 1973, we have now saved 80% of the 1985 production of OPEC and nearly 100% of OPEC production today. I believe that if we had not reduced the need for this oil and gas, it could only have come from imports, since our domestic production is steadily declining.

Figure 1b tells the same story for the OECD, which include all of North America, Western Europe, and Japan. Our combined OECD annual energy bill is $900 B, but (compared to 1973 efficiency) we have saved $250 B/year. Our oil+gas savings are 1.5 OPECs (at 1985 production rates). Because of the North Sea, OECD production of oil and gas is still rising, but nowhere near enough to supply the 1.5 OPECs that we have saved. So, again, OECD imports would be nearly 1.5 OPECs higher, and I leave it to you to guess what the price of oil might be or how much worse our national security would be. I conclude that conservation is buying us valuable time, and we should continue to support this winning strategy.

Figures 1a and 1b cover only 20 years, so the decline in production does not appear very steep. Lest you be deceived, I present Fig. 2 on US oil production, which goes out past 2020, when my children will still be paying energy bills but living without much domestic oil. The figure comes from "Beyond Oil" [1] by the Complex Systems Research Center, of the University of New Hampshire. It shows our inexorable decline in oil production. To emphasize this, its authors point out that in the 1950s we discovered 50 barrels of oil for every barrel invested in drilling and pumping. Today the ratio is 5:1, and by about 2000 it will drop to 1:1, at which time domestic exploration will become uneconomical. I find it a cogent argument for expanding conservation R&D.

Figure 3 (taken from Electrical World) is the electric industry construction side of the conservation success of Fig. 1. During the power plant overbuilding spree around 1980, we invested $50 B/year (12% of our annual capital investment in plant and equipment). Now we have 50-100 baseload plants (about 1000 MW each) in excess of current need, and utility construction is predicted by Electrical World first to fall to $17 B (leaving another 10% more of our capital formation for other productive investment), and then to rise to $40 B as electrical demand continues to grow at 2%/year. R&D today leading to more efficient use of electricity in 1995, can greatly delay and mitigate the need for this looming $40 B annual investment. Under Section III-B, Least-Cost Utility Planning, I will return to this topic.

Figure 1 showed that conservation has now saved us $150 B/year, and we have cut our energy bill to "only" 11% of our GNP. But the French spend only 7%, and the Japanese only 6%. "Least-cost" calculations show that optimal investment would halve our energy use by the turn of the century (see Fig. 4). To me, this suggests the following analogy: At 1973 efficiency we would be pouring $590 B worth of energy into a pipeline each year and getting out only $220 B in energy services. The rest--$370 B--would have leaked out. But we've plugged more than a third of the leaks, and we now waste only $220 B a year, so we only pour in $440 B worth. We can patch the rest of the leaks--and halve what we pour in--three to five times cheaper than it would cost to let them dribble. So our first priority should be to finish plugging them, before we invest more in new supply. The longer we let the leaks continue, the quicker we will exhaust cheap, secure sources of oil and gas. Seeking new supplies--"draining American first"-- while we still use energy unwisely just hastens the depletion of our reserves; heightened efficiency saves the energy until its really needed.

And how much has it cost to plug the leak? So far, because we have been skimming the cream, conservation has typically been five times cheaper than purchasing energy. So to save $150 B/year, we have probably invested $30 B/year, leaving a net savings of $120 B/year. In terms of incentive programs by government or utilities, we can do even better than 5:1. PG&E, the giant Northern California utility, boasts that in 1985 it spent $0.25 B on conservation programs, but avoided committing $1.75 B to new supply, a benefit/cost of 7:1. To save the next $200 B/year, some of the cream will be gone, and least-cost analysts estimate that conservation will only be three times cheaper than supply.

I-B. Technological Triumphs of DOE-supported R&D

Technical successes of DOE-sponsored Buildings R&D were well documented in a 1986 Conservation White Paper [2], so I will summarize only a few points and reproduce its main table (here labeled Table 1).

Case histories were presented for three important technical developments: high-frequency, solid-state ballasts for fluorescent lamps (Fig. 5), "heat-mirror" (low-E) window films, and improved refrigeration. The paybacks on federal R&D funding were typically 5000:1, but the delay times are long, partly because the buildings industry is so fragmented (see Table 2). Thus, at LBL we started to develop the heat mirror film in 1975, but it will not reach 50% market penetration until 2000 (25 years), and the majority of existing windows will not be replaced until 2020 (45 years). So to save scarce energy for our children, we must support R&D today.

The savings from these three completed projects are astounding: more than $10 B/year when they finally saturate the market (even at today's prices and for today's floor space). This equals the yearly output of about 25 baseload power plants and an oil+gas saving equivalent to half the yearly output of the Alaska pipeline.

In addition to saving energy, conservation has also saved some US industries and created others. The $1 B/year US ballast market would have been invaded by the Japanese and the Europeans had it not been for US development of the solid-state ballasts. In California we have two new industries based on the "heat mirror" films: Southwall Technologies sells low-E coated plastic to window manufacturers. Airco Solar products sells multi-million dollar plants for sputtering the thin films on glass.

I conclude from the data in this section that it has paid us very well to develop new technologies, and that they will become commercial in America several years sooner than if we had waited for either domestic or overseas markets to develop them. In the case of the examples above, several years' acceleration of savings of $17 B/year (sum of Row 8 of Table 1) represents a savings to US ratepayers of $50 B.

II. Reviews and Comments by Advisory Panels

Since the current Administration is committed to halving the budget for Conservation R&D, it cannot be expected to give our work rave reviews.

However, DOE/Conservation maintains an excellent and thorough program review of each of its Offices. For example, the Assistant Secretary recently organized a review of the Office of Buildings and Community Systems, held at LBL in October, 1986. DOE invited representatives from industry, academia, and research organizations such as EPRI, GRI, NAHB-RC, and private consultants.

Some of the Panel Chairman have circulated their Panel Summaries, which are very favorable, and I shall quote two.

1. The Building Systems Integration Panel Summary was written by Jerold J. Jones, Professor of Mechanical Engineering at the University of Texas, Austin, who has been a leader in studying and writing the Series 90 consensus building standards adopted by ASHRAE (American Society of of Heating, Refrigerating, and Air-conditioning Engineers). Jones writes:

"General Comments.

"The Panel, in their discussions, was very much aware that energy is no longer considered a 'crisis' and that there are very real pressures to reduce expenditures for energy conservation and renewable resource research. We are aware that the Nation's attention has been refocused on issues of National security, international competition, productivity and deficit spending. However, those participating in the review remain convinced that conserving energy and reducing the $165 billion annual bill for energy used in the buildings sector of the US economy are important elements in addressing and resolving each of these issues as well as in conserving our National resources and protecting our environment.

"Recognizing that there are limitations on the funds that are available we would urge DOE to carefully examine the level of its support to each of the conservation areas; industry, transportation and buildings. We would recommend that DOE focus resources in those areas where there is a high potential for successfully reducing energy use and cost and a low probability that adequate research support could be generated in the private sector. We feel that the estimate that OBCS programs could displace the use of 10 Quads of energy use, and effect a $60 billion (in 1986 dollars) cost savings, in 2010 is conservative. As the buildings industry is diffuse, even fragmented, there are few sources of research support. This is especially true with regard to building and systems integration issues. There is some history of modest research investment in product areas, building materials or equipment, for example, but even this most often has been directed towards sales and a company's, or industry components', position in a very competitive marketplace. It is not uncommon to find a company's R&D budget under the direction of its marketing department. With increasing economic pressure and lessening public concern for energy, many of these development programs are being discontinued. Private sector research and development is decreasing. In the broader context of building energy use and efficiency, there is no resource other than ASHRAE's approximately $1 million research expenditure, for work which examines overall issues. An Engineering News Record article (July 31, p. 229) noted that in 1984 the automotive and aerospace industries in the US invested about 4% in research, the Japanese construction industry invested about 3% and US construction only about 0.01%. There is clearly a Federal role in stimulating and supporting research in the buildings area. We therefore urge OBCS, and DOE as a whole, to seek to support buildings systems integration related research at the highest level possible."

2. The Building Equipment Panel Summary was written by Dr. Fritz Kalhammer, Vice President and Director of Energy Management and Utilization at EPRI. He writes:

"The Working Group also debated the possibility of indicating in semi-qualitative ways, the funding levels appropriate for individual program elements. We abandoned this approach when it became apparent that current funding for most if not all of the program elements is marginal, considering the very large societal benefits that are promised by successful developments. Indeed, the probability for technoeconomic success--and thus for the realization of these benefits--would increase substantially were additional funding available."

DOE/Conservation also holds regular reviews of major programs within an office like OBCS. Thus, the Fenestration Research Review Panel just met this month in Berkeley; the chair of this mainly industrial group was William Griffith of the National Fenestration Council. In his Executive Summary he writes:

"The Fenestration Program was seen as under-emphasized within the OBCS conservation program, relative to its strong potential for achieving long-term energy savings for the nation. It is an excellent program with world-class researchers and facilities, and a uniquely integrated research approach to its important subject area. It has suffered from inadequate and uncertain funding, yet it has achieved notable results. These have benefited the entire building industry, from product manufacturers to building designers."

The Subcommittee may want to obtain the complete reviews from DOE/Conservation.

III. Two High-Potential Current Programs

It is fairly easy to defend the development of specific technologies, because one can see them penetrate the market and be installed in buildings. The Conservation White Paper (ACEEE, 1986) has addressed three technologies, but in this section I want to defend two more general programs relating to Building Systems and to Analysis and Technology Transfer.

III-A. Energy Performance Calculations: the DOE-2 Program and the Energy Kernel System

Recent budget history:	
FY 86 Appropriated	$ 762K
FY 87 Appropriated	600
FY 88 Request	0
FY 88 I will argue for	650

In 1976, the California Energy Commission and US-ERDA started supporting LBL to write Cal-ERDA, the first public-domain energy analysis computer program designed to be widely used by building designers and researchers, and by those in California and ASHRAE writing building standards and guidelines. DOE, after absorbing ERDA, has continued to support and modernize Cal-ERDA under the names of DOE-1 and DOE-2.

These tools are so well validated and documented that they have become the US reference standard programs; thus California approves simplified programs to assess compliance with its energy code based on their reasonable agreement with DOE-2. ASHRAE used the DOE-2 program to upgrade its Series 90 standards for new buildings, which will be adopted by most states and will be mandatory for federal buildings. DOE-2 is now used in many countries of Western Europe, and even in China and Singapore.

In the US, a single major architecture firm, Skidmore, Owings and Merrill, made 2400 DOE-2 runs in '86, and reports that this thorough analysis typically shaves 20% off their current design guidelines.

As is well known, in the last ten years redesign, mainly with computer tools, has shaved 50% off the fuel use of cars and airplanes and about two-thirds off the energy use of buildings. A glass-walled, over-lit, poorly-controlled 1973 office building has an annual energy bill of $3/square foot at today's energy prices. A building conforming to ASHRAE Standard 90, with the same first cost, gets by on $1/square foot, an annual saving of $2/square foot. In the 10 years since the Cal-ERDA/DOE-2 tools became available, we have constructed 20 billion new square feet of residential plus commercial building space, so we are saving about $40 B/year. I would credit our energy calculation tools with a few percent of these savings, or something like $1 B/year. Performance calculations have clearly been a great success.

But DOE-2 is growing obsolete. It is a large, ten-year-old mainframe Fortran program which is hard to link to modern "CAD" software and is not capable of being combined with similar programs which have been written in other countries. We have therefore started a multi-national collaboration to write the Energy Kernel System, the next-generation, modular, internationally compatible program, which can run under any CAD system, and which can also be simplified to run on personal computers. If the DOE-series programs get credit for saving $1 B/year, the Energy Kernel System should be worth many billions more. Such an international effort will not be funded by normal market forces--it needs Federal support. I should point out that although we initiated this collaboration, our funding has been so shaky that its leadership is gradually drifting to Europe. In particular, the UK is planning to commit 60 man-years to EKS.

III-B. Least-Cost Utility Planning Project

Recent budget summary:

FY'86 appropriation $1 M
FY'87 appropriation $1 M
FY'88 There are three points of view:
- --The administration request is zero.
- --In FY'86 the House Committee on Science and Technology authorized $4 M for 3 years, so $2 M remains for FY'88.
- --I will argue for this $2 M for this year, and another 3-year $10 M authorization starting in FY'89.

* * * * *

I have already introduced Fig. 3, from Electrical World, with its wild oscillations in construction, as an example of the current planning problems of utilities.

Two founders of this notion of "Least-Cost Energy Services" were Roger Sant, in Washington, DC, and my group in Berkeley. Jointly we invented "Conservation Supply Curves," and for ten years we at LBL have done least-cost studies for DOE (the SERI Solar/Conservation Study, 1981), states (California, Texas, Michigan), and utilities (including BPA). We have developed a technology data base where a utility planner can look up the benefits and costs of may "demand-side" measures for buildings, e.g., efficient appliances, thermal storage, or weatherization. Recently we have been adding information on consumer response to various incentive programs, including some interesting data and experience from overseas.

But we are not alone. EPRI has developed a similar data base, but for electric options only; GRI has information on gas end-use options; several utilities and PUC's have partial data bases; and NARUC (National Association of Regulatory Utility Commissioners) is starting to collect information on regulatory issues and experience.

When the House Science and Technology Committee authorized $4 M for 3 years to LBL and NARUC, we (LBL, NARUC, EPRI, GRI) wanted to combine all this information into a currently merged public data base, as shown in Fig. 6, and to collaborate with DOE's Energy Information System at Oak Ridge to bring the titles of many unpublished utility and state agency reports and papers into the public domain. We calculated that these projects would need about $1 M/year for several years.

Since DOE continually requests zero funding for the Least-Cost Initiatives, it is naturally reluctant to start an ambitious data project, no matter how valuable. Instead, DOE has allocated a major share of the first two years of funding to implement a thoughtful and popular but quite different program, such as helping NARUC to set up an electronic bulletin board and to publish a primer on least-cost planning. Notably, DOE has solicited proposals from many groups and utilities for co-funding of least-cost planning projects, and has set aside $500,000 to fund some fraction of the 57 proposals which they have received.

I praise and defend the current DOE program, which is seeding a ferment of ideas in an important field, but it is *not* as yet funding the essential task, which is to merge and modernize the technology data base and the document base, make them available to utility planners, and work with utilities and states on serious least-cost studies.

The best way out of this dilemma seems to be to continue and expand the funding, so as to be able to carry out both the tasks of Fig. 6 and to continue DOE's popular program solicitations, as described above.

As mentioned above, society is now paying about $1 B annual interest on power plants which had to be abandoned because of inadequate planning. Let us spend a few million dollars now to help avoid such colossal mistakes on the next cycle of construction.

IV. New Initiatives

The DOE budget for Conservation R&D has dropped from $600 M in FY'80 to $152 M in FY'87. Under such conditions, individual programs still manage to complete projects and start new ones, but it is very difficult to initiate entirely new programs or research directions. At our LBL Center, we have proposed dozens of exciting, cost-effective initiatives but have been able to start only one, and few of our ideas make it into DOE planning.

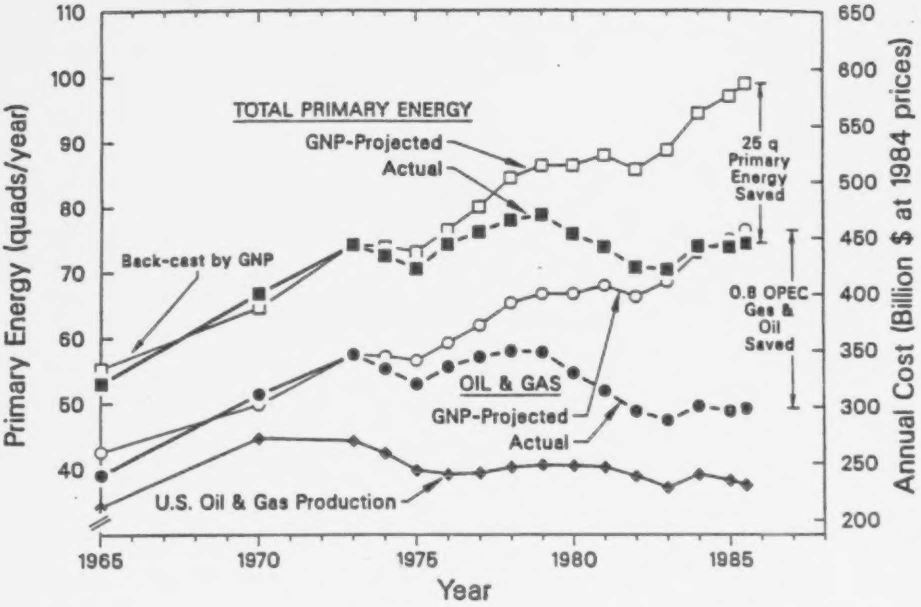
Fortunately the Washington-based coalition who combined to sponsor the Alternative Conservation Budget have come up with a list of 10 Initiatives, which merit serious consideration.

Citations

[1] "Beyond Oil: The Threat to Food and Fuel in the Coming Decades," (summary report) produced by the Complex Systems Research Center, University of New Hampshire, Ballinger Publishing Co., 1986.

[2] "Federal R&D on Energy Efficiency: A $50 Billion Contribution to the U.S. Economy," a White Paper on the Consequences of Proposed FY 1987 Budget Cuts, by the American Council for an Energy-Efficient Economy and the Energy Conservation Coalition, March, 1986.

Fig. 1a.



XCG 861-7060 A

Fig. 1a. U.S. ENERGY USE: ACTUAL AND PROJECTED BY GNP. Projected energy calculated on a GNP basis in constant $, with both forecast and back-cast values from 1973. Note how well GNP back-cast follows the actual consumption curve before OPEC. The "primary energy" of the left-hand scale included fuel burned back at the power plant, in units of "quads" [quadrillion (10**15) Btu.] The energy savings were converted from quads to "OPEC"s using 1985 OPEC production of 16 Million barrels per day = 32 quads. For the right-hand cost curve, quads were converted to 1985 dollars using the 1985 US cost of energy, about $400 billion. (updated 86-12-21)

Fig. 1b.

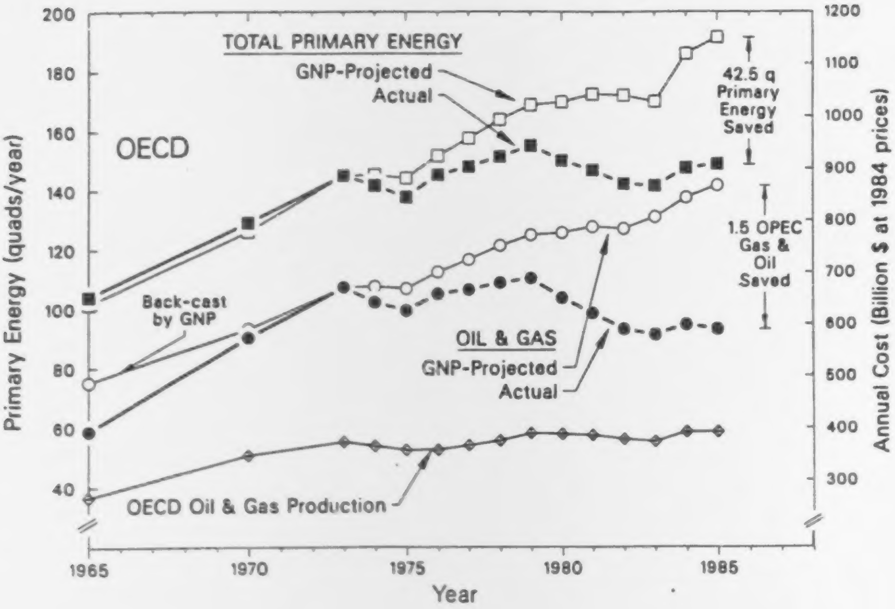


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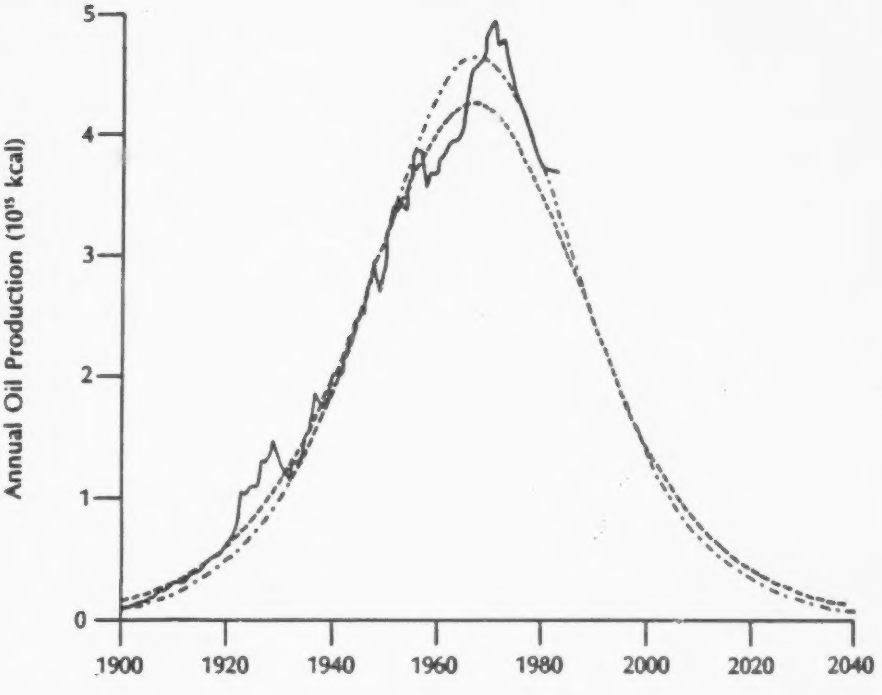
Fig. 1b. OECD ENERGY USE, i.e., same as Fig. 1a, except that the OECD includes all of North America, Western Europe, Japan, and Australasia, and consumes about twice as much total resource energy as the US alone. Annual dollar savings are $250 B for all energy, and 1.5 OPECs for oil-plus-gas. Sources: British Petroleum Statistical Review of World Energy, 1986; International Financial Statistics Yearbook, 1987; and Energy Balance of OECD Countries, 1976.

Fig. 2.

Figure 2. Comparison of Hubbert Curve to Actual Production



Solid line represents actual production; dotted line is Hubbert's 1956 curve; dashed-dotted line is our updated curve based on 1981 data.

Sources: U.S. Department of Commerce, Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970* (Washington, D.C.: USGPO, 1975); U.S. Department of Energy, *Monthly Energy Review* (Washington, D.C.: DOE, various years).

Fig. 3.

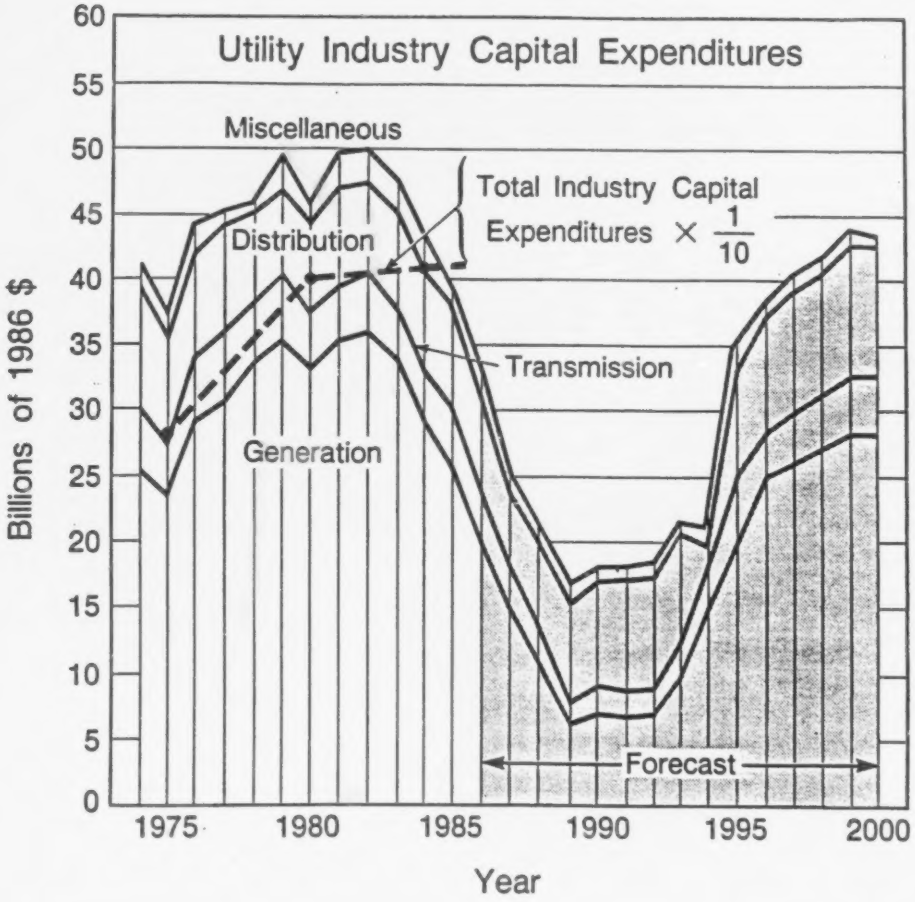


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Figure 3. Electrical industry annual investment in plant and equipment, in 1986$. The equivalent investment by all of industry is about $1B per day, so that the electric fraction has dropped from about 15% ($50B) to a minimum that will be about 5% ($17B). The utility investments do not include cogeneration, which is running at about $2B/year. Source: Electrical World, McGraw-Hill, Inc., Sept. 1986. Figures for total industry investment are from *1986 Statistical Abstract of the United States,* 106th Edition, Table 901, p. 529, using GNP implicit price deflators to convert to 1986 dollars.

Fig. 4.

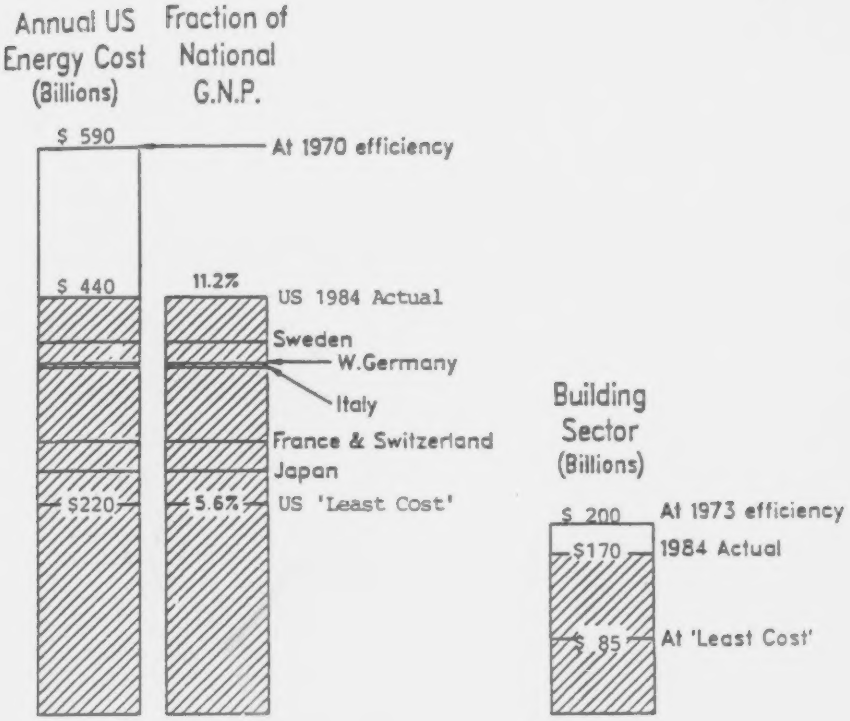
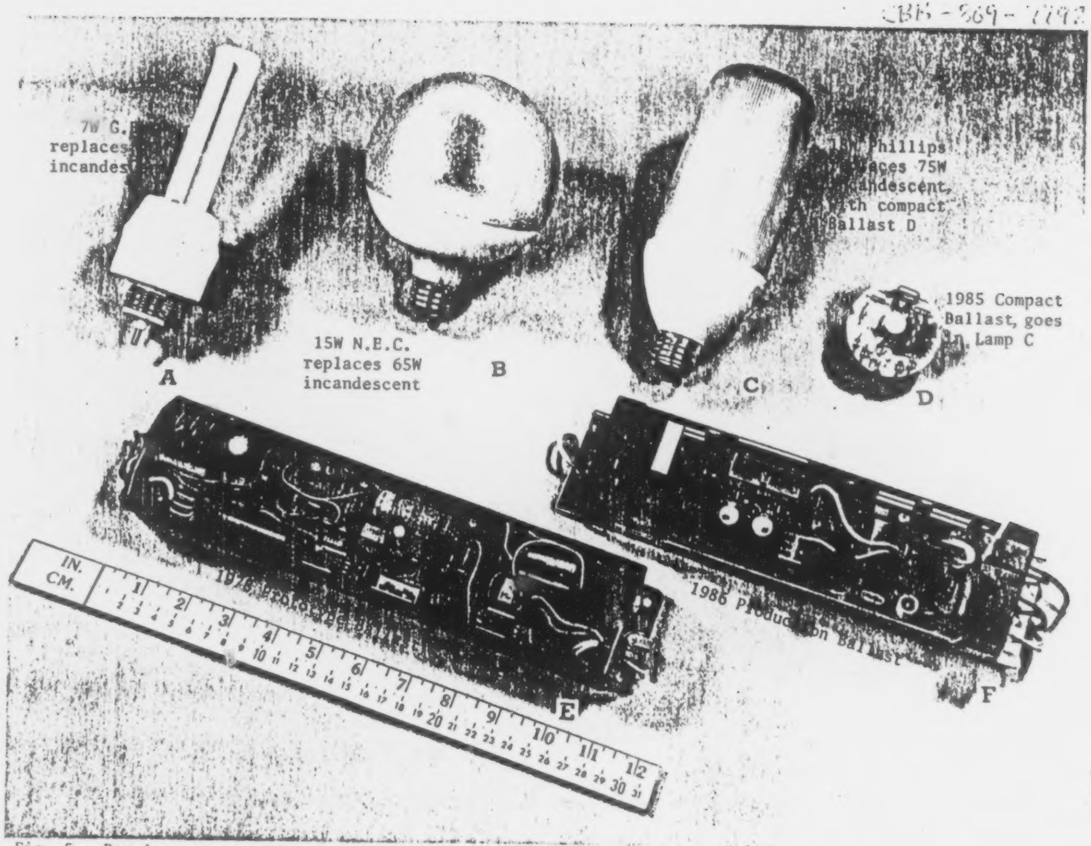


Fig. 4. ANNUAL U.S. ENERGY COST. Energy use per $ of GNP (in constant $) has dropped to 74% from 1970 to 1984; if efficiencies had stayed frozen at 1970 values our $440 annual cost today would instead be $440 B/0.74 = $590 B. On right bar, "Fraction of National GNP" are lines representing 1984 fractions for European countries and Japan. These lines show what the 1984 U.S. economy would pay for energy at foreign efficiencies.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1978 Prototype
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1986 Production Ballast
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Fig. 5. Development, starting in 1978, of high-frequency, solid-state ballasts for fluorescent lamps, first the long tubes, later compact fluorescents to replace less efficient incandescents.

Fig. 5.

Table 1.

Table 1. Lead-times and Net Savings for Successful DOE-Sponsored Buildings Energy R&D Projects.

	Solid State Ballasts	Low-E Window Films	Residential Absorption Heat Pump	Advanced Electric Heat Pump	High Efficiency Refrigerator Compressor	High Efficiency Refrigerator -Freezer	Heat Pump Water Heater
1. Start of DOE Project	1976	1976	1978	1977	1977	1978	1977
2. Completion of DOE Project	1980	1990[D]	1988	1986	1981	1983	1982
3. Est. 50% Penetration of Sales	1995	2000	2001	1998	1990	1996	1995
4. Years by which DOE advanced commercialization	5 yrs.	5 yrs.	5 yrs.	2 yrs.	2 yrs.	2 yrs.	3 yrs.
5. Cost of Conserved Energy, (CCE)	2¢/kWh	$2/MBtu	$2.50/MBtu	$2.75/MBtu	1¢/kWh	3¢/kWh	3¢/kWh
6. Cost of DOE Project	$3M	$2M	$6.8M	$2M	$1M	$0.8M	$0.7M
7. Net Annual Savings in 1985	$11M	$14M	$0M	$0M	$0.4M	$0.2M	$6.5M
8. Net Annual Savings at Saturation	$5,000M	$3,000M	$2,400M	$2,500M	$1,100M	$850M	$3,000M
9. Cumulative Net Savings (Line 8 x line 4)	$25,000M	$13,000M	$12,000M	$5,000M	$2,200M	$1,700M	$9,000M
10. DOE Project ROI (Return on Investment (Line 9 ÷ line 6)	8,000: 1	7,000 : 1	1,500 : 1	2,500 : 1	2,000 : 1	2,000 : 1	13,000 : 1

Notes:

A. All dollar savings in energy costs are net of increased costs for purchase of the improved equipment (ballast, window, etc.).

B. Line 5. Cost of Conserved Energy, CCE. We use a real discount rate d = 7%, and the useful life of the product: e.g. - 10 years for ballasts, 20 years for windows. The CCE of low-E films, now still a novelty, is currently $4/MBtu, but as the market matures, we estimate that the CCE will drop to $2/MBtu.

C. Line 8. Net Annual Savings at Saturation are in 1985$, uncorrected for: growth in the building stock, changes in real energy costs, or discounted future values. We decided not to account explicitly for these three factors, since all three are uncertain and their combined impact probably small, as follows:
To translate savings in 2000 or 2010 to 1985 terms, one should multiply by exp $[(g + e - d)T]$, with the following annual rates:

$$\left.\begin{array}{l} g = \text{growth rate of building sector (3\%)} \\ e = \text{real price escalation for electricity or fuel (1-2\%)} \\ d = \text{real discount rate (4-7\%)} \end{array}\right\} \quad g + e - d = (-3 \text{ to } +1\%)$$

T = years between 1985 and the est. saturation date, 20 - 25 years.

D. As indicated on line 7, 70m sq.ft. of first generation soft-coat were already installed in 1985, but this soft-coat can be used only between sealed double glazing. Current R&D aims to increase the durability and applicability of sputtered coatings and to produce additional engineering data to better utilize the coatings in sunbelt climates and in commercial buildings.

Source: Federal R&D on Energy Efficiency: A $50B Contribution to the US Economy, a White Paper on the Consequences of Proposed FY'87 Budget Cuts, by the American Council for an Energy-Efficient Economy and the Energy Conservation Coalition. March 4, 1986.

TABLE 2.

Size & Diversity of the Buildings Sector

- New construction totaled $340 billion in 1985 (9% of GNP)
- The cost of energy consumed in the buildings sector totaled $165 billion in 1985
- The construction industry is:
  - Over 28,000 homebuilders
  - Over 150,000 special trade contracting establishments
- The construction material and component manufacturing industries are also fragmented:
  - Over 600 manufacturers of non-electric heating equipment
  - Over 100 manufacturers of mineral wool insulation
- Each new building requires inputs from more than 50 industrial sectors

Source: DOE Assistant Secretary's Review of Office of Buildings and Community Systems, LBL, October, 1986.

Table 2.

STATEMENT OF MARC LEDBETTER, AMERICAN COUNCIL FOR AN ENERGY-EFFICIENT ECONOMY

Mr. LEDBETTER. I hope it is apparent why I asked Art to go first. I wanted the Committee to be given a complete explanation about what kind of opportunity there is out there for conservation and how enormously successful it's been so that the recommendations that I can make for conservation R&D spending make sense. I appreciate you letting me go last.

I represent the American Council for an Energy-Efficient Economy which is a non-profit research organization that promotes energy efficiency. I am going to spend most of my time talking about an alternative budget that our organization has helped develop, but before explaining that I am going to quickly touch on the issue of international competition and how federal involvement in energy conservation R&D can help U.S. firms to compete in the area of energy efficient products.

I am going to give you a few examples of where Federal involvement has helped, or some examples of where we are threatened from foreign technologies.

The first example is in the area of power electronics. This now an area—Maybe I should define power electronics before going on. It's basically the industry that is built up around electronic controls that control power consuming equipment, motors and whatnot. Presently U.S. industry controls about 50 percent of that market. The rest is controlled by foreign importers. The market is growing rapidly. It is very important, and many foreign competitors are finding all kinds of new applications for power electronics. Just as a quick example, the Japanese are now installing variable speed drives on their washing machines that we all use at home, and they have found that this substantially reduces the power consumption of those. It enables the washing machine motor to exactly match the amount of power it needs to wash any size load. It not only improves the performance of the washing machine, but it ends up substantially improving. I am not going to belabor that point. I'm sorry I got off on the wrong track.

Anyway, I started out saying that 50 percent of the market is controlled by American manufacturers, and as a consequence, the foreign imports in this area, people that are experts in this area, particularly Ralph Ferroro, who is starting a research institute in Tennessee—it is going to be called the Power Electronics Research Institute—expects that the American control of this market is going to quickly erode to about 25 percent by the year 1990. So we are seeing a very rapid erosion of this market. Control is going to foreign competitors.

Another example of a current American industry that is being threatened by foreign imports is room air conditioners. Just in 1983 for the first time we saw Japanese import room air conditioners in this country. In a very short period of time, between 1983 and 1985, we saw Sanyo, Panasonic, and Dykin take over five percent of the market, and we are seeing very rapid expansion of that.

The Americans feel the pressure from foreign energy efficient imports. Carrier Corporation has now decided to bring manufacturing room air conditioners in Brazil. They are using energy efficient rotary compressors on these air conditioners. They are not using their outdated American technology on this.

Senator **Fowler**. Is Japanese technology in air conditioners something that American technology does not have?

Mr. **Ledbetter**. Right now American manufacturers are not manufacturing rotary compressors for room air conditioners, that's correct. I can't say whether——

Senator **Fowler**. Why? Why would they say they are not?

Mr. **Ledbetter**. I imagine it is a combination of many factors, one of which would be the technology. I am sure it is a combination of a number of factors. I am pointing this out as an example, though, of just an area that could be helped with more technological development in the United States.

Another area in which we are seeing foreign imports threaten the American industry is in the area of housing. This threat is not immediate, but I think it is imminent. The threat that I'm mentioning is the threat posed by manufacturers of factory-made housing in foreign countries.

The industry has come a long way in several foreign countries, particularly in Sweden, Denmark, and in Japan, and all these countries are seeing high quality, esthetically pleasing, energy efficient housing made. We are finding that the Japanese are looking very seriously at the American market. They are interested in bringing their homes here. The Swedish, as a matter of fact, have already started importing their homes into this country. These homes are relatively expensive right now in the American market. It is largely due to the distance they have to transport these things.

Nevertheless, they are getting a foothold in the American market. Unless the American home industry is able to respond, we are going to see a steady erosion of the portion of the market they control.

Now, as I said, I was going to make a quick reference to international competition and then go on to an alternative energy budget that our organization is promoting. I will do that now.

This budget was developed through extensive effort by quite a number of organizations. Many of them were consumer organizations, environmental organizations, some industry groups, some professional organizations, one organization of state energy officials. These people had expertise in the conservation R&D program, reviewed it point by point, and looked for opportunities to increase spending on these programs, opportunities for effectively in—or opportunities for increasing the effectiveness of these programs, and also looked for opportunities in savings. They ended up producing what I think is an impressive document that contains a very sound recommendation for conservation R&D spending for the coming fiscal year.

Now the reason these groups developed this budget is because we are seeing that the leadership in directing these programs is wanning within the Department of Energy. The recommendation coming out of the Department of Energy for these programs has declined steadily since 1980. As a matter of fact, the Administration's request for funding for these programs in fiscal year 1988 is nothing more than 14 percent of the appropriation these programs received in 1980. So we have seen steady erosion, and year after year the request is ratcheted down and we see these programs suffer. Art mentioned some people that he is laying off, and I am sure many of the national labs are going through the same kind of experience.

The alternative budget recommends a fairly modest increase in energy conservation R&D spending. We are recommending that for existing programs they receive $171.9 million, which is six percent over FY-1987 funding. As you can see, it is very modest.

We chose to take that modest route because we wanted to be taken seriously by Congress. It is very easy for organizations promoting programs they are interested in to come up here and make very large requests and justify them with all kinds of good reasons, but it is another thing to come up here and recommend something that is within the ability of Congress to consider. We realize the enormous budget pressures the Congress is under, so we wanted to make a recommendation that was moderate and reasonable, and we think we have done that.

In addition to the $171 million recommendation we have made for existing programs, we have recommended an additional $20.25 million for new initiatives which Art referred to a minute ago. We think there are a number of areas that deserve the attention of Congress, that deserve funding, areas that are being passed over right now because of budget constaints. Many of these technologies that we have included in the new initiative offer enormous opportunity for reducing energy consumption cost effectively in the country.

Senator Fowler. Just for the record, Mr. Ledbetter, how does the $171 million that you propose as an alternative compare with the Administration's request?

Mr. Ledbetter. The Administration's request for these programs is a small amount over $80 million.

Senator Fowler. On top of that you are proposing, how much for new initiatives?

Mr. Ledbetter. Another $20 million. So the total alternative budget request is the $171 for existing programs, plus $20 for the new initiatives. That total is $192 million which is 19 percent over the FY-1987 appropriation.

I was going to mention a couple of examples of the new initiatives just to give you an idea of the kinds of things that we are recommending in our budget.

Senator Fowler. Do that quickly because we are about to vote, and I want us to have a little discussion.

Mr. Ledbetter. I will do it very quickly. You asked Art Rosenfeld a question about lighting technology, and he started talking about some of the remaining technologies, or the remaining potential in improving the efficiency of lighting.

One of the technologies that we have included in this new initiatives list is a program that would help the national laboratories develop what is called a two boton phosphor. Basically increase the efficiency of the phosphors that cook inside of florescent tubes. The same people that developed the electronic ballast that Art Rosenfeld was mentioning earlier are the people that think this kind of technology could reduce energy consumption by florescent lighting by about 40 percent.

It is a very substantial reduction. Art mentioned I don't know how many power plants were devoted to——

Dr. **Rosenfeld**. That would be a 40 power plant savings.

Mr. **Ledbetter**. We spend about $16 billion a year on florescent lighting. So you can see a 40 percent reduction in florescent lighting would be very valuable to the country.

Just one last example of new initiatives that we are recommending, and that is in the area of factory made housing. We are proposing that the Department of Energy be given $2 million to start a program in helping American industry move toward developing a factory-made housing industry, a high quality, energy efficient home. We are not talking about the existing generation of factory-made housing. We are really talking about a whole new generation of housing, a whole new type of housing.

I brought this up at a hearing over on the House side and I was asked a couple of questions about what these homes looked like, whether they were very large. I got the impression that the subcommittee that I was testifying before thought that we were basically talking about a remake of the existing manufactured housing in the United States, but we are not.

I brought along some pictures to help this subcommittee.

Senator **Fowler**. It helps to show pictures.

Mr. **Ledbetter**. We have wonderful pictures. I hope you can see this. This is a Japanese manufactured house. I am sure you can't see many of the other pictures contained in my brochure here, but you can flip through here and see that these homes are very esthetically pleasing. They are very beautiful homes. The quality of the manufacturing is quite high. That is the kind of thing that we are talking about in this new initiative, taking existing research that has been done on buildings, integrating that into this program, working with industry, doing a review of of the state of the technology for manufacturing these kinds of home, and basically get the program rolling so we can have American industry respond to the foreign imports we are seeing. I'll leave it there.

[The prepared statement of Mr. Ledbetter follows:]

TESTIMONY OF THE AMERICAN COUNCIL FOR AN ENERGY-EFFICIENT ECONOMY

ON
ENERGY CONSERVATION R&D

BEFORE THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON ENERGY AND NATURAL RESOURCES
U.S. SENATE

MARCH 26, 1987

Mr. Chairman, and members of the Subcommittee, my name is Marc Ledbetter. I'm testifying on behalf of the American Council for an Energy-Efficient Economy , which is a private, non-profit organization that researches and disseminates information on energy efficiency. My remarks concern the Department of Energy's conservation R&D programs and an alternative budget for these programs that my organization helped develop.

Since the economic turmoil created by the oil crises of 1973 and 1979, energy efficiency has been an important force in moving our economy back onto the path of growth. Energy use per unit of GNP dropped 24% between 1973 and 1985. Had the U.S. continued to consume energy at the wasteful rate it did in 1973, its 1985 energy bill would have been about $130 billion higher. (This estimate doesn't even include economic savings from the decline in oil and gas prices since 1981, for which energy efficiency can take much of the credit.)

Much of the improvement in U.S. energy efficiency has been driven by technological change. New industrial processes, more efficient automobiles, more efficient building designs, and improvements in the efficiency of energy using equipment were spawned by the energy troubles of the 1970's. The pace of technological development in many of these areas has quickened in recent years. An energy efficiency technology battle is taking shape, and unfortunately, foreign competitors are gaining in many areas. Federal conservation R&D programs are needed to help U.S. companies meet this technological challenge.

The fast growing market in power electronics is one such area of intense competition. According to Ralph Ferraro, a former employee of the Electric Power Research Institute, widespread use of new electronic controls is causing fundamental changes in energy-using devices and processes. For example, Japanese companies are placing electronics-controlled, variable speed drives in washing machines instead of conventional mechanical transmissions. This enables the wash-basket motor to determine the exact amount of electricity needed for a load of wash, which can greatly reduce the amount of energy consumed. Japanese companies are years ahead of U.S. companies in this area.

Ferraro says that U.S. manufacturers presently control about 50% of the domestic power electronics market, but that amount will probably erode to about 25% within five years. According to the Federation of Materials Societies, "if the current trend continues, it can be anticipated that the U.S. will be a minor force in the world market in electronic materials and systems by the 1990's."

Electronics can improve the performance of many kinds of motors. Heat pumps can be more precisely controlled to reduce energy consumption and improve indoor comfort. The jolt of electricity delivered to electric motors during start up can be eliminated. Instead, these motors can be "soft-started" with electronics so the motors will consume the same amount of energy at start up as they will during operation.

Efficiency improvements are also being made to the motors themselves. New permanent magnet motors have 20% lower power losses than the best induction motors. A recent study on efficiency electric motors concluded:

> U.S. competitiveness in this rapidly growing market for new motor technologies is of concern, however. As pointed out by the National Materials Advisory Board, 'The fundamental work leading to the REPMs [Rare-Earth Permanent Magnets] was done largely in the U.S... but after government support ceased, materials R&D in the U.S. magnets industry deteriorated. Practically all recent permanent magnet materials have been developed to commercial maturity in Japan.'

New electronic controls are also being applied to lighting. In fact, DOE's lighting research program developed the first solid state electronic ballast in the U.S., which reduces energy consumption from fluorescent lights by 15-30% and allows adjustments to lighting levels to precisely match needs. When the research program was begun in 1976, none of the major ballast manufacturers showed any interest, nor did they respond to a request for proposals to cost share initial development. However, with the cooperation of several small manufacturers, DOE successfully developed the new ballasts. Major U.S. ballast manufacturers finally began producing solid state ballasts in 1984, but only after foreign competitors had entered the U.S. market. Major ballast manufacturers expect electronic ballasts to grow from 1% of the market in 1985 to 50% in 1995. Incredibly, total DOE funding for ballast research over the nine years has only been $2.7 million, yet in the five years by which DOE advanced commercialization of the ballast, savings to the

U.S. economy are expected to reach $25 billion (an 8000 to 1 return on investment of federal dollars).

DOE has advanced the commercialization of numerous other technologies. A recent draft DOE report entitled Energy Conservation Program Success Stories lists 22 new commercialized technologies developed through DOE conservation R&D programs.

Another example of intense competition from efficient foreign products can be found in the room air conditioner industry. Panasonic, Sanyo and Daikin began marketing efficient, quiet room air conditioners in the U.S. in 1983. By 1985, the Japanese had captured 5% of the market. General Electric is now phasing out production of room air conditioners at its main factory in Louisville, Kentucky, and intends to replace its production by purchasing more efficient Japanese air conditioners. Carrier Corporation has started assembling room air conditioners in Brazil using efficient rotary compressors made in Japan. Despite these incursions by efficient foreign products into a consumer appliance market once controlled by U.S. companies, DOE R&D on efficient consumer appliances has been limited to very low levels since 1984.

A final example of American industry facing increased competition from energy efficient foreign products is in the area of housing technology. Sweden supports an aggressive housing technology R&D program that supports a growing industry producing high-quality, "super-insulated", factory-made houses. Swedish funding for this program is approximately the same as U.S. government support for building R&D even though the Swedish housing market is 1/20 as large as the U.S. market. Swedish firms are now exporting these houses to the U.S. Japanese companies are also producing high-quality, factory-made houses that are being considered for export to the U.S.

Clearly, energy efficiency plays a large role in the marketability of energy consuming devices and processes. Although the U.S. has made major efficiency advances in many products, many of these are now being overtaken by more efficient foreign products. An energy efficiency technology race is on among the industrial countries of the world, and if U.S. government support for development of new efficient technology continues down the path of repeated program cuts and terminations, the U.S. will surely lose the race. (In contrast, the Japanese just increased their government spending on conservation R&D by 7%). Private U.S. companies cannot and will not do the needed research on their own -- the risks and costs are too high. Strong federal support of conservation R&D should be a high priority of this Congress.

Because of the strong boost that federal energy conservation R&D programs can provide to U.S. industrial competitiveness and general economic strength, we urge this subcommittee to recommend increased funding for these programs. Specifically, we ask that this subcommittee recommend adoption of the funding levels for federal energy conservation R&D programs contained in the attached alternative budget for energy conservation. The alternative budget covers both R&D and State and Local Programs. All of my comments will be on the R&D portion of the budget.

The alternative budget is a detailed and comprehensive budget recommendation for federal energy conservation programs. The recommendations for existing programs were built from the ground up. Experts in conservation R&D reviewed each individual subprogram for its importance to the overall federal conservation effort, and its funding needs. Needed funding increases as well as possible savings were identified and included in the recommendations. The resulting recommendations provide a minimum base level of support for existing programs.

Developing this alternative budget was not an easy task. Dozens of organizations with expertise in conservation programs and technologies took more than two months to research, come to a consensus on funding levels, and write the budget.

These organizations undertook this enormous job because the Administration has steadily reduced its commitment to supporting conservation R&D. Instead, the Administration has supported deep funding cuts that have and will terminate or severely curtail dozens of worthwhile R&D projects. The Administration appears willing to surrender world leadership in conservation R&D. Given the incredible track record of conservation's role in restoring the United States' economic health, and given the enormous success of so many federally-supported R&D projects, it's sadly ironic that the Administration's budget request for conservation R&D is now only 14% (in constant dollars) of the FY 1980 appropriation for these programs. The Administration's unreasonably low budget request is all the more ironic in light of the recent Department of Energy report, Energy Security, that warns of a rapidly rising oil imports.

The alternative budget recommends a moderate increase in funding for existing conservation R&D programs, from $161.7 million in FY 1987 to $171.9 million in FY 1988, a 6% increase. In addition, the alternative budget recommends $20.25 million for new initiatives, which brings the total conservation R&D request to $192 million, about 19% above FY 1987 funding.

We could easily have justified larger increases for many of the conservation R&D programs. In fact, DOE's own multi-year plan for energy conservation R&D, which is based on extensive industry involvement, calls for substantially higher funding. However, we understand the predicament Congress faces with the federal deficit, and therefore proposed much more modest funding levels in hope that Congress would seriously consider the alternative budget.

Among the new initiatives included in the alternative budget is a project to develop more efficient fluorescent lamp phosphors. Lighting by fluorescent lamps consumes about $16 billion worth of electrical energy each year in the U.S. However, by improving the efficiency with which these lamps convert ultra violet radiation to light, it is possible to greatly reduce energy consumed by fluorescent lamps. Experts in lighting technology believe it is possible to use improved phosphors -- the coating on the inside of fluorescent lamp tubes that emit light -- to reduce energy used by fluorescent lamps by about 40%. The same experts developed with DOE support the electronic ballast for fluorescent lamps mentioned earlier in this testimony. Considering the remarkable success of that program, these experts should not be denied the funding they need to pursue another major lighting innovation. We recommend first-year funding of $.25 million for the project.

Another new initiative is a cooperative effort among private industry and federal and state agencies to create technologically-advanced, energy-efficient, and aesthetically-pleasing factory-made housing. The new technology could develop into a whole new multi-billion dollar industry that would help American manufacturers respond to the challenge of Swedish and Japanese factory-made house imports.

This program would establish three regional centers that would, through cooperative arrangements with states, universities, and private companies:

1) Identify the state of technology in factory-made housing. This would include identifying innovative technologies for design and building techniques in the U.S. and abroad.

2) Study policy and marketing issues related to factory housing including zoning laws, building codes, and buyer attitudes.

3) Conduct research on low-cost, high-quality materials, construction techniques, and research and develop design technologies and software to increase design flexibility.

4) Develop methods for integrating existing and future energy technologies into factory-made housing.

5) Research and develop methods for reducing on-site assembly costs, and perform demonstration studies of manufactured buildings to establish reliable technical

> performance and cost information bases. This information will allow better understanding of how various factors affect construction and operating costs, and minimize investment risk by industry.

We recommend first year funding of $2 million for this initiative.

As a last example of the new initiatives we propose, we recommend that a center be established for monitoring international energy conservation R&D. Many countries have ambitious programs in energy efficiency R&D. If made aware of their research results, U.S. researchers could benefit greatly; U.S. researchers could avoid "reinventing the wheel," and take advantage of much high quality information that is available for the asking. Many foreign countries have long monitored U.S. efforts in this area. It's time the U.S. commits itself to the same kind of effort. We propose first-year funding for this project of $.50 million.

We recognize that the need to reduce the federal deficit makes it difficult to justify increased funding for any program. However, R&D is basic to the health of the U.S. economy and the ability of the U.S. to compete in international markets. Given this nation's massive energy bill (approximately $400 billion annually), energy conservation's track record of helping to keep this bill down, and the enormous potential for further reductions in energy use, increased funding for energy conservation R&D is a wise investment for this country, even in times of tight federal budgets.

FEDERAL R&D ON ENERGY EFFICIENCY
A $50 BILLION CONTRIBUTION TO THE U.S. ECONOMY

A White Paper on the Consequences of Proposed FY 1987 Budget Cuts

by:

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March 4, 1986

PART A: BENEFITS OF THE FEDERAL R&D PROGRAM

Executive Summary

The Administration's 1987 budget proposes to cut federal energy conservation research and development by 60 %, on top of previous budget reductions totaling nearly 50 % since 1980. The U.S. already spends far less on conservation R&D per unit of energy consumption than most industrialized countries. Further cuts, if implemented, would weaken our national security, cost U.S. consumers billions of dollars in excess energy costs each year--even with lower oil prices--and run counter to the Administration's stated goal of reducing the national deficit. Part A of this White Paper explains the compelling economic and security reasons for maintaining federal energy conservation R&D at least at current funding levels:

- There is a **broad national consensus on the need to increase energy productivity** in all sectors. Improved energy efficiency will reduce the multi-billion dollar annual drain on our economy, buy us the time to diversify our long-term energy options, and mitigate a number of our most pressing environmental problems.
- We have **already made huge gains** in reducing energy use per dollar of GNP. If today's economy still operated at the wasteful level of 1973, we would be **importing four times as much oil** and spending an **extra $150 billion per year** for energy.

- The U.S. economy can **still achieve large, cost-effective improvements in energy efficiency**. In addition to the gains of the past decade, energy efficiency can still **increase at least 30 percent** across all sectors of the economy.
- **Federal R&D programs have played an important role** in bringing about these savings, and **can contribute even more** in the future. The case studies in Part B show how federal support for energy conservation R&D, by advancing the commercial adoption of new technology, saves billions of dollars for industry and consumers. For these seven case studies (see **Table A.1**), federal investments totaling $16 million generate eventual savings of **$68 billion**. This represents a **return on the taxpayers' investment of 4400 to 1**! Of course, not all R&D efforts can produce such dramatic payoffs, but even if these seven projects had to justify the *entire* federal investment in energy conservation R&D over the past decade, they would represent a 50:1 return.
- Continued advances in energy-saving technology can play a key role in **assuring the competitiveness of U.S. industry** in the world market. Experience shows that well-conceived federal R&D can reinforce private industry initiatives. Conversely, a federal retreat may open the way for aggressive firms overseas—often with their own governments' backing—to gain the edge in both U.S. and world markets.
- The **federal government has a vital role** in carrying out energy conservation research, development, and technology-transfer. Without active federal participation, important technological advances would often be hampered by industry fragmentation, market structure, or the non-capturable ("public good") nature of basic research. Both U.S. industries and consumers benefit directly from energy conservation R&D, but if the federal government withdraws, the private sector cannot take up all the slack.
- Federal energy conservation R&D **contributes significantly to the underlying policy objectives of the Gramm-Rudman-Hollings legislation**: the easing of pressure on capital markets, in order to free up funds for productive investments. Disproportionate cuts in these programs would thus undermine the aims of our national economic policy.

These views are strongly supported by the recent report on Long-Range Energy R&D Strategy, prepared by the Demand Subpanel of DOE's Energy Research Advisory Board. [ERAB, 1986] The next sections examine each of the above points in more detail. Then, in Part B, we present a series of case studies of the enormous payoff from R&D on buildings-sector energy technologies.

1. Increased Energy Efficiency is an Important National Goal

Over the past decade, Americans have developed a broad consensus on the goal of improving energy productivity throughout the economy. Both the current and previous Administrations and the Congressional leadership of both Parties have properly emphasized energy efficiency as a cornerstone of our national energy policy.

Perhaps less well-known is the enormous progress made to date. Where would we be today without the significant changes in energy efficiency achieved over the past decade?

Figure 1 provides a broad perspective. If energy use per unit of GNP were the same in 1984 as it was in 1973, the U.S. would be spending 35 percent more for energy--an **extra $150 billion per year**. Slower growth in energy demand has meant a savings of 13 million barrels/day (oil equivalent) in our current needs for oil and gas, representing nearly **three times our total U.S. oil imports**.

Had we not made these substantial gains in energy productivity, our present energy situation would look radically different. We would be facing $150 billion per year in extra energy costs, and additional oil imports of 13 million barrels/day. In consequence, our trade deficit problems would be even more severe. Oil prices would still be high, since this extra U.S. demand would maintain the pressure on world supply at the margin. OPEC would still play a dominant role; our major sources of energy supply would be far more vulnerable--as would our strategic position in the Middle East. The economy would continue to suffer from high prices of energy-intensive goods and services. Finally, the public would be clamoring for solutions to all of these problems, in an atmosphere of even more severe budget imbalance.

Since energy demand growth has been reduced, the present U.S. energy situation is manageable, at least for the near future. Clearly, market forces have played a major role: slower economic growth has helped to dampen energy demand and higher energy prices have discouraged many wasteful practices by industry and consumers. A substantial contribution, according to DOE-sponsored studies, has also come from increased technical efficiency in homes, automobiles, and factories—partly in response to price signals but also reinforced by government policies and programs. For example, increased fuel economy of cars and light trucks, compared to 1972 levels, saved an estimated 1.5 million barrels/day of fuel in 1984, worth over $18 billion to consumers. [DOE/OPPA, 1985]

The good news is that we do not face an energy crisis today. The bad news is that, faced with a short-term oil glut, we run the risk of ignoring the future consequences of a finite supply of world oil reserves. How effectively will we use the "breathing room" we have earned? And, in the meantime, how long must we continue to pay for the wasteful patterns of energy use that are built into the existing capital stock?

2. Large Increases in Energy Efficiency Can Still be Achieved

The lower rate of energy demand growth that has occurred since 1973 (Figure 1) might suggest that most of the waste has been squeezed out of the U.S. economy. This is not the case. To date, much of the reduction in demand growth has resulted from belt-tightening and changes in wasteful patterns of behavior. Only a portion of the savings have come from investments in improved, energy-efficient technology.

Numerous studies suggest that, in addition to the gains already made, the U.S. could reduce its present annual energy bill from $430 billion to $300 billion or less, by adopting only those efficiency measures that are now available and economically justified. [SERI, 1981; Texas PUC, 1986; Meier et al., 1983] Most of the U.S. stock of energy-using equipment and buildings was put in place when energy prices were low, and stock turnover is slow in many sectors. So it is not surprising that much of the existing physical plant wastes energy.

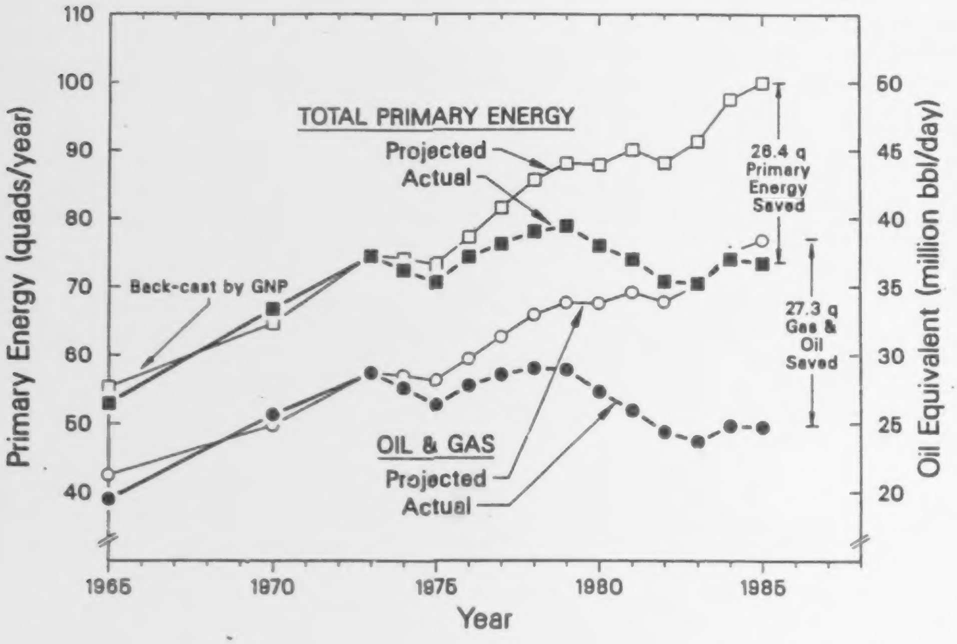

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Figure 1. **U.S. Energy Use, Actual and Projected by GNP.**
Projected energy calculated based on GNP, in constant $, with both forecast and back-cast values from 1973. Note how well GNP back-cast follows the actual consumption curve before OPEC. The 74 q used in 1984 cost end-users $430 B. Source: Monthly Energy Review published December 1985 and EIA Annual Report to Congress.

It is important to note that these opportunities for cost-effective energy savings are **not affected much by the recent decline in world oil prices.*** This is especially true for the buildings sector, which is increasingly electricity-intensive (in 1984, U.S. buildings consumed $100 billion of electricity but only $65 billion of oil and gas). Nationally, retail electricity prices are quite insensitive to changes in the cost of oil (or natural gas). This point is illustrated in **Figure 2**, which shows powerplant fuel costs, in constant dollars, as a fraction of the average U.S. retail electricity price, to all sectors, from 1980 through 1985.

Figure 2 shows that, while the overall cost per kilowatt-hour has changed very little in the past six years in real dollars (after inflation), fuel costs actually **declined** from 35 percent of the total to 26 percent. This decline was roughly offset by increases in other utility expenses, notably the rapid rise in capital costs for new powerplants entering utility rate-bases. Oil costs for electricity generation have declined even more dramatically than total fuel costs, largely due to fuel-shifting and replacement of older oil-fired plants. **Oil now represents, on average, less than 3 percent of the total retail price of electricity**, or about 2/10 of a cent per kilowatt-hour. Thus, even if the *average* oil price paid by electric utilities—not just the well publicized spot-market price—were cut in half, there would be almost no noticeable effect on the average price of electricity paid by U.S. consumers.

There are still important gains to be made in the fuel efficiency of buildings and equipment, but in the future, energy conservation R&D for the buildings sector will increasingly emphasize more efficient use of electricity, including the shifting of loads from peak to off-peak periods. As we have seen, the economic value of these electricity conservation and load-shaping measures will not be affected significantly by oil price changes, regardless of their magnitude.

How does today's energy use in the U.S. compare with that of other industrialized countries? The answer is that, per unit of GNP, we still use as much as 75 percent more energy than some of our major trading partners—and competitors. Japan and France, for example, each spend about 6 to 7 percent of their gross national product on energy, compared with 11.2 percent for the U.S. [IEA, 1985]

A key issue for the 1990's is whether capital investment in *new* facilities and equipment is as energy-efficient as it could be, in light of current energy prices and technology. The short answer is no; on average, today's new capital investments are still far from optimal. A typical new building, which will be in use for the next 50 to 75 years, still requires almost twice as much energy as one designed and equipped to minimize the total costs of energy, construction, and operation. [Piette et al., 1986]

Energy efficiency of the average new household appliance is also well below that of the best unit available--and even farther below the level of performance that is technically achievable and economic. **Figures 3a** and **3b** show these relationships for energy use in 1985 by: (1) the average gas and electric appliance in all U.S. households, (2) the average new appliance purchased, (3) the most efficient unit available on the market,

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* Overall conclusions from the studies cited would change very little if they were updated to 1986 conditions. Oil prices would be lower in the near-term, but gas and electricity price assumptions in the studies are still valid. Also, several energy-saving technologies not previously considered are now commercially available.

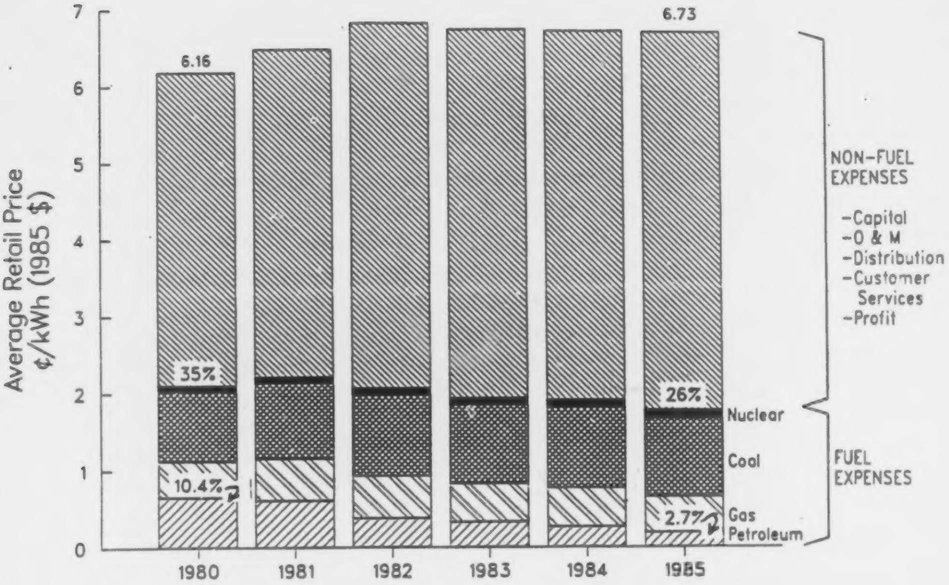

Figure 2. Fuel expenses as a component of the average U.S. retail price of electricity (in constant 1985 $), 1980 to 1985. Note that in real dollars, the average electricity price per kilowatt-hour (to all sectors) has changed little in six years, while the fuel component has declined from 35 percent to 26 percent. Non-fuel expenses, especially capital costs of new powerplants, have offset lower fuel costs. Oil costs have dropped even more dramatically, from 10 percent in 1980 to less than 3 percent in 1985. Even if the average cost of oil to utilities were to drop 50 percent, the average retail price per kWh would decline by only about 1/10 of a cent. Other cost increases would quickly offset any such decline.

and (4) an estimate of the best unit that could be made available to consumers in the mid-1990's. The Figures show that, in many cases, today's **best** product is already 30-40 percent more efficient than the average new unit purchased. Within a few years, industry leaders could be marketing household appliances that reduce energy use by another 40-50 percent.

For an individual appliance, the energy savings may be modest, but the aggregate numbers are impressive. One year of electric appliance sales represents the amount of energy produced by six large, 1000-MW baseload powerplants. This would drop to two powerplants, if all new models were as efficient as the best projected 1990's technology shown in Figure 3b.

A similar story can be told for energy-using capital equipment in industry: typical energy consumption of new stock could often be reduced dramatically with cost-effective investments [Ross, 1985]. Similarly, the fleet-average efficiency of new automobiles could be raised from 27 mpg to about 40 mpg at a cost of under $1/gallon of gasoline saved. [Fahrenwald and Herendeen, 1982; Bleviss, 1984]

In summary, the best buildings, appliances, and cars now on the market are already 30-40 percent more efficient than today's average stock, but the gradual introduction of this technology will not get the U.S. ratio of energy/GNP down to the level of Japan or France. To achieve that, in the next 20 years, will require pressing forward with technology now on the drawing board—in other words, maintaining a strong national R&D program targeted to industry's needs. In the next sections, we discuss the past successes and future potential of the federal program.

3. The Federal Energy Conservation R&D Program Has Achieved Dramatic Successes and Holds the Promise of Continued Success

We now turn to the basic issue: how well has the federal R&D program served the nation?

Table A.1 quantifies the dramatic returns on investment generated by DOE-sponsored R&D in the buildings sector. Additional detail is provided in the case studies in Part B of this paper. Each of these technologies will yield extremely large payoffs once they reach market saturation; three had already demonstrated significant commercial success by 1985 (solid-state ballasts, low-emissivity window films, and heat-pump water heaters).

By way of example, let us consider the first three technologies in Table A.1: solid-state ballasts, low-emissivity window films, and residential absorption heat pumps.

- The total government cost of these three projects is less than $12 million, thanks to DOE cost-sharing with private industry.
- Two of the three projects (the third is not yet commercial) have **already produced** annual net savings* far greater than the total federal R&D investment over several years. In other words, a *one-time* federal investment of $5 million for the two projects has already generated an *annual* return of $25 million—or over 500 percent per year.

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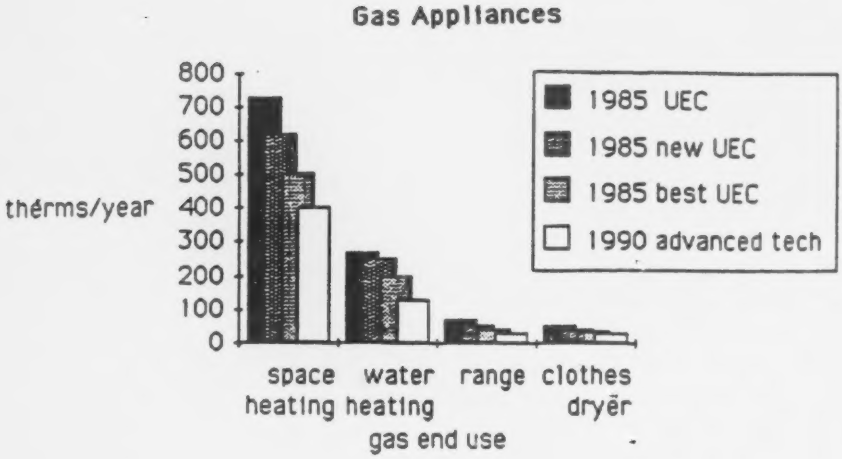
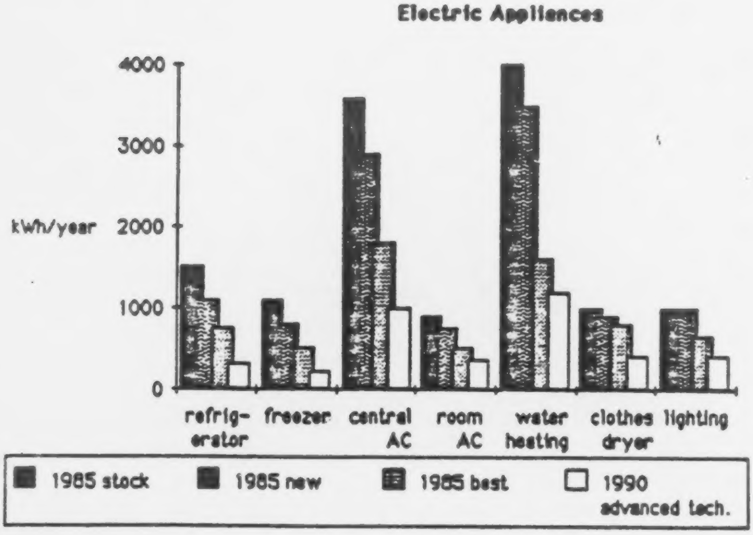
* Net savings = annual energy savings minus the increase in (annualized) capital cost to buy the more efficient products.





Figures 3a and 3b. Unit Energy Consumption of Gas and Electric Household Appliances in the U.S. Each set of bars compares energy use by the average model in the 1985 stock, the average new unit and best new unit sold in 1985, and the best technology expected to be available in the 1990's. For scale, note that the electric appliances sold in just one year use as much electricity as is produced by six large, 1000-MW powerplants. This would drop to two powerplants if all new models were as efficient as the best 1990's technology. Source: H. Geller, American Council for an Energy Efficient Economy

- The near-term benefits are small, however, compared with the eventual impact from full market saturation of these new technologies. Taken together, they will **ultimately save U.S. consumers over $10 billion per year**.
- However, we must assume that, eventually, these technologies would have been developed commercially even without federal R&D support. The government should take credit only for accelerating the market—by about 5 years, in these three cases. Thus, the net benefit of federal involvement in these three projects is 5 years times $10 billion/year, or roughly **$50 billion**. This represents an **extraordinary 4000 to 1 return to the taxpayer on an initial investment of only $12 million.**

The other projects shown in Table A.1 also show substantial net savings, and handsome returns on the federal R&D investment.

Table A.1 illustrates another important point: the long lead-times involved in research, development, and successful commercial adoption of a new technology. DOE research on solid-state electronic ballasts, for example, began in 1976 and lasted until 1980. Despite relatively high turnover rates for replacing fluorescent ballasts, it will probably take until the mid-1990's for them to reach 50 percent market saturation. This perspective makes it clear that well-targeted R&D can have a major impact if it advances the eventual commercialization date by only a few years.

Additional examples of high-impact R&D projects are provided in the 1985 DOE Conservation Multiyear Plan. **Table A.2**, reproduced from the DOE Plan (page 12), contains a list of 18 projects, mostly from the industrial sector, that have led to new technologies that are commercially available today. All were supported, fully or in part, by the DOE conservation programs. DOE estimates energy savings from these 18 projects at approximately $16 billion *per year* by the year 2010.

There are still other examples outside the industrial sector. For example, DOE-sponsored R&D on advanced ceramics for turbines and other vehicle engines could generate well over 1 quad of *annual* fuel savings by the year 2015, representing benefits of over $7 billion/year. All this for a projected total federal investment of $239 million. [Johnson, et al.]

Energy efficiency research, as these examples make clear, is far from an academic exercise. The total federal investment in energy conservation research, less than $200 million per year, has already paid off dramatically in bottom-line economics.

These statements should not be misunderstood to suggest that all government energy conservation research projects are successful. Many projects have succeeded, as documented in Tables 1-2 and in the case studies (Part B). But others have failed to work as hoped, or have been slow in achieving commercial acceptance. This is inherent in research programs--in fact without such risk factors there would be less justification for federal involvement.

However, this same point illustrates an important advantage of R&D on end-use energy efficiency: R&D efforts are *diversified*, so the consequences of a single failure can be offset by other successes. By contrast, when government or private resources are concentrated on a few large-scale projects—as with some energy supply technologies—any failure or setback becomes all the more costly, in terms of both wasted dollars and lost time.

Table A.1. Lead-times and Net Savings for Successful DOE-Sponsored Buildings Energy R&D Projects.

	Solid State Ballasts	Low-E Window Films	Residential Absorption Heat Pump	Advanced Electric Heat Pump	High Efficiency Refrigerator Compressor	High Efficiency Refrigerator -Freezer	Heat Pump Water Heater
1. DOE Project Duration	1976-1980	1976-1990[D]	1978-1988	1977-1986	1977-1981	1978-1983	1977-1982
2. Est. 50% Penetration of Sales	1995	2000	2001	1998	1990	1996	1995
3. Years by which DOE advanced commercialization	5 yrs.	5 yrs.	5 yrs.	2 yrs.	2 yrs.	2 yrs.	3 yrs.
4. Cost of Conserved Energy, (CCE)	2¢/kWh	$2/MBtu	$2.50/MBtu	$2.75/MBtu	1¢/kWh	3¢/kWh	3¢/kWh
5. Cost of DOE Project	$3M	$2M	$6.8M	$2M	$1M	$0.8M	$0.7M
6. Net Annual Savings in 1985	$11M	$14M	$0M	$0M	$0.4M	$0.2M	$6.5M
7. Net Annual Savings at Saturation (i.e. 10-15 after 50% penetration)	$5,000M	$3,000M	$2,400M	$2,500M	$1,100M	$850M	$3,000M
8. Cumulative Net Savings (Line 7 x line 3)	$25,000M	$13,000M	$12,000M	$5,000M	$2,200M	$1,700M	$9,000M
9. DOE Project ROI (Return on Investment, =Line 8 ÷ line 5)	8,000: 1	7,000 : 1	1,500 : 1	2,500 : 1	2,000 : 1	2,000 : 1	13,000 : 1

Notes:

A. All dollar savings in energy costs are net of increased costs for purchase of the improved equipment (ballast, window, etc.).

B. Line 4. Cost of Conserved Energy, CCE. We use a real discount rate $d = 7\%$, and the useful life of the product: e.g. - 10 years for ballasts, 20 years for windows. The CCE of low-E films, now still a novelty, is currently $4/MBtu, but as the market matures, we estimate that the CCE will drop to $2/MBtu.

C. Line 7. Net Annual Savings at Saturation are in 1985$, uncorrected for: growth in the building stock, changes in real energy costs, or discounted future values. We decided not to account explicitly for these three factors, since all three are uncertain and their combined impact probably small, as shown by the following calculation. To translate savings in 2000 or 2010 to 1985 terms, one multiplies by: $\exp[(g + e - d)T]$, with the following annual rates:

$$\left.\begin{array}{l} g = \text{growth rate of building sector (3\%)} \\ e = \text{real price escalation for electricity or fuel (1-2\%)} \\ d = \text{real discount rate (4-7\%)} \end{array}\right\} \quad g + e - d = (-3 \text{ to } +1\%)$$

T = years between 1985 and the est. saturation date, 20 - 25 years.

D. As indicated on line 6, 70m sq.ft. of first generation soft-coat were already installed in 1985, but this soft-coat can be used only between sealed double glazing. Current R&D aims to increase the durability and applicability of sputtered coatings and to produce additional engineering data to better utilize the coatings in sunbelt climates and in commercial buildings.

Source: See case studies, Part B.

TABLE A.2. Selected Completed Conservation Technologies (Partial List)

Technology (Year Completed)	10^{12} Btu/ Year*	10^6 \$ Savings**
Cogeneration-Coal Fired Steam Turbine (1983)	344	1,720
Cogeneration-Slow Speed Diesel (1983)	516	2,580
Computer Controlled Oven (1981)	228	1,140
Controlled Speed Accessory Drive (1981)	31	155
Cupola Stack Air Injection (1981)	25	125
Dye Bath Reuse (1979)	19	95
Foam Finishing (1980)	52	260
Heat Exchanger-Dryer (1982)	59	295
Heat Pump Water Heater (1980)	410	2,050
High Efficiency Welding Unit (1979)	42	210
Nitrogen-Methanol Carburization (1981)	10	50
ORC Bottoming Unit (1981)	225	1,125
Plastic Wastes to Fuel (1982)	88	440
Plating Waste Concentrator (1981)	22	110
Recuperators-AiResearch (1979)	178	890
Recuperators-GTE (1979)	247	1,235
Slot Forge Furnace (1978)	20	100
Solid State Ballast (1980)	660	3,300
Totals:	3,176	15,880

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* Estimates of national energy savings projected in the year 2010, given the market penetration performance history of these technologies.

** The projected annual dollar value of energy savings in the year 2010 estimated at \$5 per 10^6 Btu.

Source: FY 1987 Energy Conservation Multi-Year Plan, July 1985, Office of Conservation, US DOE.

[Editor's note, Table A.2. This table, reproduced from the DOE Multi-Year Plan, shows gross savings of \$3.3 B from solid-state ballasts in 2010. Our estimate in Table 1 is that net savings, at saturation, will be about \$5 B. The difference is due to three factors, in addition to the gross vs net savings discussed in notes to Table 1: (1) We assume actual 1985 average electricity costs (7.5¢/kWh) while the DOE document assumes 4.5¢/kWh (based on \$5/MBtu for all energy). (2) We assume eventual full saturation of the 250 BkWh used for fluorescent lighting in the U.S. in 1985; DOE's assumed baseline usage is 200 BkWh. (3) Our figure assumes 33% average savings, including reduced cooling loads and savings from improved control of lighting levels; DOE assumes an average savings of 25% per ballast.]

4. Advances in Energy-Efficient Technologies Are Needed to Assure a Strong Competitive Position for U.S. Industry in the World Market

The previous section identified a number of advanced energy efficiency technologies with strong commercial potential. But who will be the technological leaders in these growth sectors, U.S. firms or their overseas competitors? The answer depends, in part, on a continued strong federal role in advanced technology R&D.

Three contrasting examples from the lighting industry illustrate this point. The first involves electronic ballasts for fluorescent lights. As discussed in Part B, DOE-supported ballast R&D played a key role in reducing technical risks, sharing information with the industry, and helping U.S. firms to bring a new product to market so as to maintain their strong domestic position.

A similar DOE-industry research program on compact, screw-in fluorescent lamps was halted in 1981--while still in its formative stage--due to federal funding cuts. By 1985, a number of Japanese and European firms were already well ahead of their U.S. counterparts in introducing advanced, high-efficiency lamps. The Illuminating Engineering Society of North America publishes an annual list of new lighting products; in 1985, 12 of the 50 items were introduced by overseas firms.

The third case is still hanging in the balance. It involves lighting controls, a market with very high growth potential over the next few years. Recent DOE-funded research has again provided much of the technical foundation for U.S. companies to establish a position of market leadership. With continued federal support, the opportunity exists for a highly successful DOE-industry collaboration to take advantage of this multi-billion dollar market.

We find a similar pattern in another high-technology product line: efficient electric motors and controls. U.S. industrial, commercial, and residential consumers pay about $80 B/year for power to run electric motors. Recent advances in magnetic materials and power electronics are greatly improving the efficiency of these motors and motor-driven systems and reducing costs to consumers. Permanent-magnet motors, for example, can have 20 percent lower losses than the best induction motors, run cooler, are smaller and lighter, and are more precisely controlled. Current applications include machine tools, robotics, computer peripherals, and home appliances.

A recent study (Baldwin, 1986) points out that:

> U.S. competitiveness in this rapidly growing market for new motor technologies is of concern, however. As pointed out by the National Materials Advisory Board, 'The fundamental work leading to the REPMs [Rare-Earth Permanent Magnets, such as SmCo] was done largely in the United States... but after government support ceased, materials R&D in the U.S. magnets industry deteriorated. Practically all recent PM materials have been developed to commercial maturity in Japan.'
>
> Thus, the NMAB concludes that 'despite the critical importance of magnetic materials, the U.S. is rapidly losing its competitive position.' And this in a market that is expected to reach $2B annually next year.

A final example is in the area of housing technology, an industry that is traditionally seen in the U.S. as fragmented and slow to accept technical innovation. Contrast our situation with that in Sweden, where the government supports an ambitious R&D

program in all aspects of basic and applied building technology. [Schipper, et al., 1985] Total funding is of the same order of magnitude as that in the U.S., even though the domestic market is only about one-twentieth the size of ours. Swedish researchers have produced a host of technical innovations that are already used in "superinsulated" houses around the world. Applications of R&D results to an industrialized building sector have made high-quality, energy-efficient homes the norm in Sweden, rather than the exception. Several firms are now exporting their factory-built housing to the U.S., and beginning to compete successfully in upscale markets.

These examples show the commercial importance of energy efficiency technologies. The opportunities are there; the key is how to help U.S. industries position themselves to best advantage. Part of the answer lies in basic and applied R&D, where the federal government, as discussed in the next section, is a crucial player.

5. There is an Essential Role for the Federal Government in Energy Conservation Research

Both private and public sector R&D is an investment in the future. Industries and nations that invest too little in R&D, or fail to pursue valuable projects to completion, will suffer losses in competitiveness, innovation, and productivity. Such losses are not always apparent for some years, but a lack of high-quality R&D inevitably cripples industries and can weaken whole economies.

Comparative data shown in **Figure 4** demonstrate that other industrialized countries often give much higher priority to government investments in energy efficiency R&D than does the U.S. [Ketoff, 1986] Using one index, conservation R&D spending per Quad of energy use (light cross-hatching in the Figure), the U.S. ranks fifth among the five countries shown. An alternative index, R&D spending as a fraction of GNP (dark cross-hatching), the U.S. ranks third—but still well below levels for France and the U.K. If the French government's program for energy conservation R&D were scaled to the U.S., it would represent between $260 and $380 million per year (according to whether the scaling factor is GNP or energy consumption). [AFME, 1986] This compares with actual U.S. conservation R&D expenditures of only $171 million for FY 1986 (including information and technology transfer), which would be further cut to $71 million under the proposed FY 1987 budget.

There are widely differing views on the appropriate federal role in energy conservation R&D. We generally concur with the following policy statement in the DOE Energy Conservation Multiyear Plan:

> The federal role in energy research and development is concentrated in areas where the incentives for and availability of private investment are severely limited or nonexistent. ... The success of federal research and development programs in providing options for private investment and commercial development depends on effective technology transfer.

DOE defines a role for federal research and development in those areas where there is little incentive or few resources available to the private sector. This policy must be interpreted in light of recent findings on the limited extent of private R&D investments in many sectors of U.S. industry. A recent study of appliance manufacturers and markets worldwide showed that U.S. firms spent only 1-2 percent of their 1983 sales revenue on all R&D (not just energy efficiency), in contrast to an estimated 3-4 percent spent by

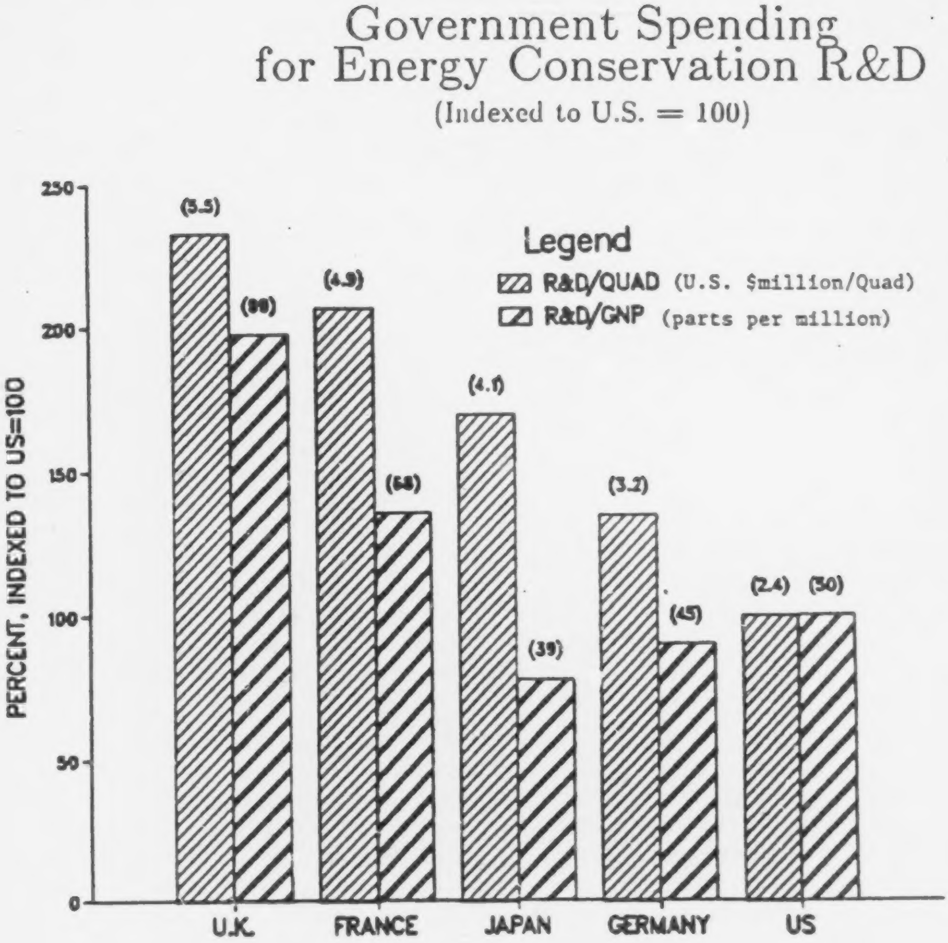

Figure 4. Government spending for energy conservation R&D in five industrialized countries. The data show that other industrialized countries often give higher priority to government spending on energy efficiency R&D than does the U.S. One index (light cross-hatching) is conservation R&D spending per Quad of energy use; the U.S. ranks fifth among the five countries shown. A second index (dark cross-hatching) is R&D spending as a fraction of GNP; the U.S. ranks third—still well below levels for France and the U.K. Source: Ketoff, 1986

Japanese appliance manufacturers. [Sterling Hobe Corp., 1984] For comparison, rapidly advancing "high-tech" industries in the U.S. typically allocate 4-7 percent of revenues to R&D. [*ibid.*]

Other reviews of R&D in the manufacturing sector find that private firms often have limited incentive or resources to undertake their own research because of high up-front costs, risks of failure, and uncertain competitive advantage from a new advance, which might be rapidly adapted or copied by other firms. Nor is it apparent that the modest federal tax incentives provided for industrial R&D have had any significant impact. [Baily and Chakrabarti, 1985]

With regards to the building industry, the recent ERAB Demand Panel report states that:

> Many small design firms, building companies, and component manufacturers comprise the building industry. Most private firms will undertake basic R&D activities if there are substantial and immediate monetary gains for the firm, and this is seldom possible in a fragmented industry of small firms. As a result, too little R&D is performed and [it] must be supplemented by the government if it is to be accomplished on any substantial scale.

The FY 1987 budget proposal urges DOE to immediately initiate joint programs with private industry, presumably to make up part of the large cuts that are planned. Collaborative, cost-shared research is generally a sound idea, and in many cases is already a feature of successful DOE-sponsored energy efficiency R&D. The flaw lies in assuming that DOE's industry partners will be willing or able to *increase* their participation, to make up for drastic reductions in federal support. In fact, the opposite will more likely occur: the private sector will be likely to reduce its own participation in step with any withdrawal of federal R&D support.

Our discussions with industry R&D leaders, including the two largest industry organizations doing research on energy efficiency (the Electric Power Research Institute and the Gas Research Institute) reveal no prospect of private industry funds that might substantially replace federal funding. Even if such private funding could be generated, it would take many years to change industry priorities and to organize new collaborations between the federal government and individual firms or industry research establishments.

We need to underscore one other essential element of DOE-funded R&D: the work on more fundamental, "technology base" activities, as opposed to specific products or devices. The result of this research is more difficult to quantify than the product-oriented R&D discussed above—but no less crucial. Industry depends on such government-sponsored research to provide a technology base upon which it can build innovative, marketable new products. The long-term nature of such research, the highly specialized expertise required, and the lack of directly marketable products limits the ability of most industries to pursue it, in the absence of a leading federal role. Cooperation has been successful in this role in the past, and must continue its support at an appropriate level.

Finally, the DOE Multiyear Plan points to the benefits of a federal technology transfer program. We agree; successful R&D needs to get into the market in order to have an impact on more efficient use of energy. Technology transfer is important and deserves adequate support. While some technology transfer occurs as built-in part of projects that DOE co-funds with industry in other R&D categories, we note that the entire budget line item "Analysis and Technology Transfer" has been reduced to $1 million in the proposed budget. This is totally inadequate for any meaningful national program.

To summarize, we endorse DOE's stated policies on the appropriate federal roles for purposes of our discussion. The issue, as stated, is one of appropriate level of government support. This depends in turn on an assessment of the magnitude of the problem, and the degree to which government activities can solve it. The problem is surely large—we are wasting $150 to $250 billion per year, and facing increasing competitive pressures from overseas industries, and depleting our own oil and gas reserves at a rate that is proportionately 8 times faster than that of the OPEC countries. [Flavin, 1985] Federal support of energy conservation R&D is a key to addressing these problems over the long term.

6. Federal Energy Conservation R&D Contributes to Underlying Policy Goals of a Lower Budget Deficit

The Gramm-Rudman-Hollings legislation recognizes the urgency of reducing the federal deficit. Why? A burgeoning national debt means higher interest rates, which threaten to stifle economic growth by competing with the private sector for available capital.

But the federal deficit is not the only drain on investment capital. The U.S. energy sector itself accounts for only about 12 percent of GNP, but represented 40 percent of total investment in plant and equipment expenditures, for all sectors, in 1982. [Goldenberg, et al., 1986] From 1979 to 1984, the oil industry invested $250 billion in oil exploration alone, without achieving a net increase in U.S. reserves at the end of the five years (i.e., new discoveries just offset production). From 1973 to 1984, the electric utility industry invested $300 billion in new power plants. The single largest drain on investment dollars—after the federal deficit—is the investment in new energy supply.

Greater efficiency in energy use also means that less capital is needed for new energy supply facilities. Of course, energy-efficient technologies also require capital investments, but these are almost always several times lower, per barrel of oil or per kilowatt-hour, than investments required for traditional sources of energy supply.

In short, *increased energy efficiency can make a significant contribution to the objective of increased capital availability and lower inflation rates that are underlying goals of a reduced federal deficit.* It makes no sense to disproportionately slash federal funds for energy conservation R&D, in the name of the very policy goals that are best achieved by energy efficiency.

Conclusion

As we have seen, the proposed 50+ percent reductions in federal energy conservation R&D funding carry a double penalty for the U.S. economy and all consumers:

(1) Given the lead-times of 20 years or more for development and commercialization of advanced energy-saving technologies, we **cannot afford to abandon or defer the R&D investments that are needed now** for long-term economic vitality.

(2) Many R&D projects also have near-term payoffs. Even with a (temporary) softening of world oil prices, we can continue to **save billions of dollars each year** from the earlier introduction of energy-efficient technologies. Reducing the nation's energy bill makes our industries more productive, slows inflation, reduces our trade deficit, and gives each consumer more money to spend in job-creating sectors of the economy.

The projected impacts and high leverage of DOE R&D funds are discussed in some detail in the preceding sections and in the case studies to follow. DOE's current R&D program contains numerous projects with the same potential for success as those already completed. These projects and their rationale are described in several DOE reports, including the Multi-Year Plan. The data provide convincing evidence of the enormous value, both now and in the long run, of a well-formulated energy conservation research effort.

We recognize that controlling the federal deficit requires strong, even painful, action. However, activities that have demonstrated their success in meeting important national needs—including the objectives of federal deficit management—must be recognized. The federal role in energy conservation R&D falls into this category. We must maintain the momentum, to avoid crippling the nation's prospects for energy and economic security in the 1990's.

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AN ALTERNATIVE PROPOSAL FOR THE FY88 ENERGY CONSERVATION BUDGET

Prepared by the Energy Conservation Coalition

ON BEHALF OF THE FOLLOWING ORGANIZATIONS:

Consumer Energy Council of America
Environmental Action
Friends of the Earth
National Association of Regulatory Utility Commissions
National Audubon Society
National Community Action Foundation
Union of Concerned Scientists

March 2, 1987

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

SUMMARY OF ESTIMATES BY APPROPRIATION BY MAJOR ACTIVITY
(dollars in thousands)

ENERGY CONSERVATION

ENERGY CONSERVATION R&D	FY 1980 Actual	FY 1986 Actual	FY 1987 Appropriation	FY 1988 Alternative	FY 1988 Request	Alternative vs. DOE Request
Transportation	$109,500	$57,457	$56,055	$55,000	$22,409	+$32,591
New Initiatives				3,200		+ 3,200
Industrial	58,200	40,708	35,026	36,500	16,035	+ 20,465
New Initiatives				5,800		+ 5,800
Buildings and Community Systems	98,300	37,862	30,450	42,725	14,578	+ 28,147
New Initiatives				10,300		+ 10,300
Multi-Sector	77,800	25,922	28,304	31,000	20,406	+ 10,594
New Initiatives				2,000		+ 2,000
Facilities	N/A	9,830	10,000	-----	-----	-----
Cooperative Venture Research and Development Pools	N/A	-----	-----	5,000	5,000	-0-
Policy and Management	N/A	1,726	1,862	1,662	1,662	-0-
Sub-Total, Conservation R&D	$343,800	$173,505	$161,697	$193,187	$80,090	+$113,097
STATE AND LOCAL ASSISTANCE PROGRAMS						
Institutional Conservation Program (Schools & Hospitals)	$143,600	$ 44,888	$ 25,170*	$ 40,050	$ 0	+ $40,050
State Energy Conservation Program (EPCA Grants)	37,800	17,903	9,400*	15,750	0	+ 15,750
Energy Extension Service	25,000	7,300	3,970*	6,750	0	+ 6,750
Weatherization Assistance Program	199,000	182,084	161,460*	162,450	0	+ 162,450
Territories Assistance	N/A	476	0	0	0	0
Program Direction	N/A	9,745	13,500	13,500	6,000	+ 7,500
Other	26,200	N/A	N/A	N/A	N/A	N/A
Sub-Total, State and Local Assistance Programs	$431,800	$262,396	$213,500	$238,500	6,000	+$232,500
TOTAL, Conservation	$775,600	$435,901	$375,197	$431,687	$86,090	+$345,597

* Under the terms of the Omnibus Reconciliation Act of 1986, and a determination by the DOE Office of Hearings and Appeals, $134 million of FY 1987 funding will be derived from the oil overcharge escrow account. An additional $66 million was appropriated for FY 1987, and is available pending an Administration recision request.

AN ALTERNATIVE PROPOSAL FOR THE FY88 ENERGY CONSERVATION BUDGET SUMMARY

Energy conservation is the fastest growing energy resource in the U.S. economy; energy efficiency improvements over the past decade have reduced America's energy bills an estimated $100-$150 billion. The Alternative Budget for Energy Conservation reflects a thoughtful and detailed assessment that balances our nation's energy needs with federal budget constraints. Energy conservation can make a significant contribution to the underlying goal of reduced Federal deficits by easing pressure on capital markets, and consequently, freeing up funds for productive investments and lowering inflation rates.

Despite requests for significant budget cuts by the Department of Energy (DOE), Congress has restored funding for essential conservation programs over the last seven years. Federal support for energy conservation is vital to ensure an efficient economy, reduce dependence on unstable oil imports, improve international competitiveness for American industry, and improve environmental quality.

The Department of Energy's proposed FY88 Budget would cut Federal conservation programs 77% below FY87 appropriation levels from $375.2 to $86.0 million. State and Local Assistance programs would be reduced from $213.5 million to $6.0 million. Conservation Research and Development (R&D) program funds face a 50% reduction from $161.7 million to $80.1 million. Unfortunately, funding for Federal conservation programs has comprised an increasingly smaller percentage of an increasingly larger DOE energy budget, e.g., conservation R&D represents merely 3% of DOE's proposed $3 billion energy R&D budget.

The Alternative Budget for Energy Conservation proposes a total of $431.7 million for Federal energy conservation programs, a 15% increase above FY87 appropriations. Conservation R&D would receive $193.2 million, while State and Local Assistance programs would receive $238.5 million.

The alternative budget for conservation R&D includes a request for approximately $21 million in new R&D initiatives, including research for such technologies as fluorescent lamps that emit twice as much light as conventional fluorescents and advanced production processes for ceramic engine parts. These new initiatives focus on emerging energy efficiency technologies that offer enormous potential for commercial applications. Continued advances in energy-saving technologies can play a key role in assuring the competitiveness of U.S. industry in the world market.

The alternative budget for State and Local Assistance programs budget reflects minimal funding levels necessary to carry out a broad range of essential and innovative energy efficiency programs in all sectors of the economy. While states are currently receiving monies from the Oil Overcharge Restitution Fund, these monies are short-term funds intended to supplement rather than supplant Federal appropriations. While current program needs still greatly exceed our alternative budget request, the alternative request ensures that every state will be able to maintain minimum funding levels for each of the four state and local programs.

BACKGROUND:
ESTABLISHING FEDERAL ENERGY PRIORITIES

Despite Congressional initiatives to restore conservation funding, Federal conservation funds were reduced from $775.6 million in 1980 to $375.2 million in 1987, a 52% decrease. Over the same time period, Appropriations for R&D have been reduced 53% from $343.8 million to to $161.7 million, while state and local programs have been cut 51%. (See graphs on page 6.)

Federal energy dollars should be appropriated based upon their potential for meeting important national needs. We recommend that DOE energy programs be evaluated according to the following criteria: cost-effectiveness (return on federal tax dollars), impact on oil imports, effect on international competitiveness, and environmental quality.

***Meeting Energy Needs Cost-Effectively** - Energy conservation has already made a significant contribution toward reducing our national energy bill, and the potential for additional cost-effective conservation investments is enormous. The Department of Energy's FY88 Energy Conservation Multi-Year Plan reports that reductions in energy intensity (energy efficiency improvements) have accounted for approximately 20 quads (quadrillion btu's) of energy savings through 1984, valued at more than $100 billion annually. Numerous studies suggest that the U.S. could reduce its present annual energy bill from $430 billion to $300 billion or less through the use of existing and new energy conservation technologies and measures.

* Reducing Oil Imports - Energy conservation can reduce oil imports and stretch the United States' diminishing domestic oil supplies. U.S. dependence on foreign oil has surged 22 percent in the last year alone, while imports from Persian Gulf countries have doubled during this same time period. Our energy predicament would look even worse without the significant strides in energy conservation that have been made over the last decade. The U.S. would now be consuming an additional 1.5 million barrels of oil per day - equivalent to the oil production of the entire state of Alaska - were it not for improvements in the fuel efficiency of the U.S. automobile fleet. Today's oil imports could be entirely displaced by low-cost efficiency improvements in America's building stock and vehicle fleet.

* Improving America's International Competitiveness - Continued advances in energy-saving technology can play a key role in assuring the competitiveness of U.S. industry in the world market. Over the past decade, American automakers lost one-fourth of the global market to fuel-efficient Japanese cars. We are now witnessing the same challenge to our domestic and global market shares from foreign competitors in lighting, air conditioning, motors, appliances, manufacturing equipment, and industrial processes. Unfortunately, as the President's Commission on Industrial Competitiveness Report noted, America has recently lost global market shares in 7 out of 10 high technology market areas, despite leadership in developing high technology products. Efficiency R&D can reverse this trend and insure against a further erosion of competitiveness.

• **Improving Environmental Quality** - Energy conservation reduces energy use, and thus, decreases environmental harm resulting from exploration, production, transportation, and consumption of energy. A 1983 National Science Foundation report concluded that energy conservation provides the single most important opportunity to ameliorate carbon dioxide accumulation, which is caused primarily by the burning of fossil fuels. Energy conservation can also play a significant role in reducing acid rain emissions, thermal and solid waste, and nuclear waste.

Energy conservation receives high marks in meeting each of these national goals, and therefore, funding for essential R&D and State/Local Assistance programs needs to be restored.

MAJOR PROGRAM AREAS OF THE ENERGY CONSERVATION BUDGET

RESEARCH AND DEVELOPMENT PROGRAMS

New R&D Initiatives - America's global competitiveness can be enhanced through bold, new and innovative energy efficiency R&D programs to augment the lean research currently in place. Under the Buildings and Community Systems Program, new initiatives include $2 million for a cooperative private/federal effort to create technologically advanced factory-built housing and $1 million in research monies for improving efficiencies of small appliances (refrigerators, freezers, heat pumps, etc.). Under the Industry R&D program, new initiatives include $3 million to establish a joint government/private sector venture to improve productivity in selected key industries and $1 million for improved sensors and controls to improve process efficiency. New transportation R&D initiatives include $.5 million for continuously-variable transmissions and $.5 million to examine advanced production processes for ceramics components. **New Initiatives Request: $21.3 million.**

Buildings and Community Systems - This program is designed to achieve the maximum, cost-effective level of energy efficiency in the nation's buildings. The Buildings subprogram supports research to: determine how buildings use energy; develop new technologies for building equipment and components (e.g. heat pumps, windows, and lighting); prepare better building design tools, standards and guidelines; improve the energy efficiency of existing buildings; and to improve indoor air quality. The Community Systems subprogram develops new technologies and techniques to improve energy efficiency and management at the community level, such as district heating and cooling systems. By accelerating the commercialization of technologies, buildings and community systems R&D programs are providing enormous savings to the nation. For instance, a one-time Federal investment of $5 million in the development of more efficient lighting controls (solid-state ballasts) and windows that reflect heat (low-emissivity windows) is projected to save users $36 billion - a return on Federal investment dollars of 7000 to 1. **Alternative request: $53.0 million.**

Industrial - DOE's Industrial conservation program advances energy efficiency for many U.S. industries including chemicals, petroleum, metals, pulp and paper, food, textiles, and machinery. The competitiveness of many industries is directly tied to energy consumption because many of America's languishing industries are energy-intensive. The Industrial R&D program emphasizes cooperative government/ industry efforts to identify technological needs for energy conservation and high priority projects not being pursued by the private sector. The program has been very successful in developing technologies and systems that are now commercially available or just entering the marketplace. For example, an R&D project, developed in conjunction with a Massachusetts firm, resulted in the first U.S. low speed diesel cogeneration system. This system has been installed in a New Jersey pharmaceutical plant and will save the firm $9 million a year. **Alternative request: $42.3 million.**

Multi-Sector - This program conducts basic research applicable to all economic sectors in the areas of combustion and thermal sciences, materials, biological and non-biological chemical conversion (such as ethanol production), and tribology (the study of friction, wear, and lubrication). In addition, the program promotes the development of promising technologies that may not otherwise be commercialized without Federal funding. The Multi-Sector budget also includes support for the National Appropriate Technology Assistance Service (NATAS), which provides individual technical responses to questions posed by homeowners, small businesses, and others. **Alternative request: $33.0 million.**

Transportation - The Transportation program is designed to develop advanced technologies for automobiles and light trucks, advanced battery designs for electric vehicles, and technological options that enhance fuel flexibility for non-petroleum fuels, such as methanol. Current research projects include the development of gas turbine engines with potential fuel efficiencies higher than conventional engines. Extensive research is also geared toward the development of structural ceramic composites and coatings, which can achieve acceptable performance levels at high temperatures. DOE supports research through cost-shared contracts with industry and research institutions, whose contributions range from 20-50%. Alternative request: $58.2 million.

STATE AND LOCAL ASSISTANCE PROGRAMS

Weatherization Assistance Program (WAP) - WAP was expressly developed to improve the energy efficiency of low-income households, particularly the elderly and handicapped, and to reduce their energy costs. National surveys have concluded that for an average expenditure of $1,100 per dwelling, annual household energy bills are reduced an average of 10-20%, stretching household budgets for other goods and services. While it is estimated that approximately 17.6 million households are eligible to receive assistance under WAP, only three million low-income residences have been weatherized as of 1986. A modest goal of completing the eligible single-family buildings and priority multi-family buildings would cost approximately $7.5 billion. **Alternative request: $162.5 million.**

Institutional Conservation Programs (ICP) - Also known as the Schools and Hospitals program, ICP was established to encourage energy conservation initiatives in the public and non-profit institutional building sector where energy consumption represents a significant percentage of operating budgets. Through FY86, the program has awarded 20,000 grants for energy conservation projects in over 57,000 schools and hospital buildings. For example, an Illinois hospital is projected to save 50% of its natural gas and 10% of its electrical consumption as a result of a $630,000 matching ICP grant for energy efficiency improvements. ICP grantees between 1980-1984 saved an average of 13% in their annual energy bill, with a cumulative energy savings totaling approximately 34.5 million barrels of oil equivalent. **Alternative request: $40.0 million.**

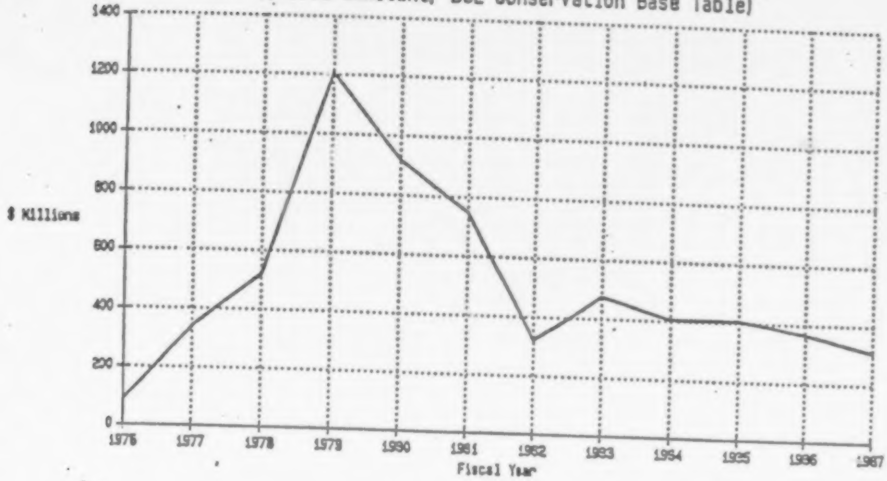
State Energy Conservation Programs (SECP) - SECP supports innovative energy efficiency programs for all sectors of the economy to help each state meet localized energy needs, while also providing substantive benefits to local economies. For instance, the Massachusetts Office of Energy Resources contracts with private-sector engineers to assist manufacturers in identifying cost-effective conservation opportunities. The Alaska Department of Community and Regional Affairs developed an energy mortgage valuation program which encourages the construction of more efficient homes by rewarding buyers with a 2% credit on the debt to income ratio. The New York State Energy Office developed a below-market interest rate loan program to finance energy efficiency improvements for small industrial and commerical firms, not-for-profit organizations and owners of multi-family dwellings. Cumulative energy savings from SECP activities totaled approximately 670.7 million barrels of oil equivalent between 1977 and 1983. **Alternative request: $15.75 million.**

Energy Extension Service (EES) - EES provides information and technical assistance for small businesses, local governments and homeowners on effective and productive energy conservation and renewable energy options. EES programs are diverse and innovative. For instance, the Washington Energy Extension Service has developed an irrigation system audit guide and a computer program on water scheduling to help farmers reduce irrigation energy costs. The Maryland Small Town Energy Education Program has assisted 30 towns in designing cost-effective conservation strategies by providing free energy audits of their municipal buildings and water treatment plants and consultations on street lighting efficiency improvements. EES programs leverage federal dollars with local funds to achieve maximum conservation benefits. **Alternative request: $6.75 million.**

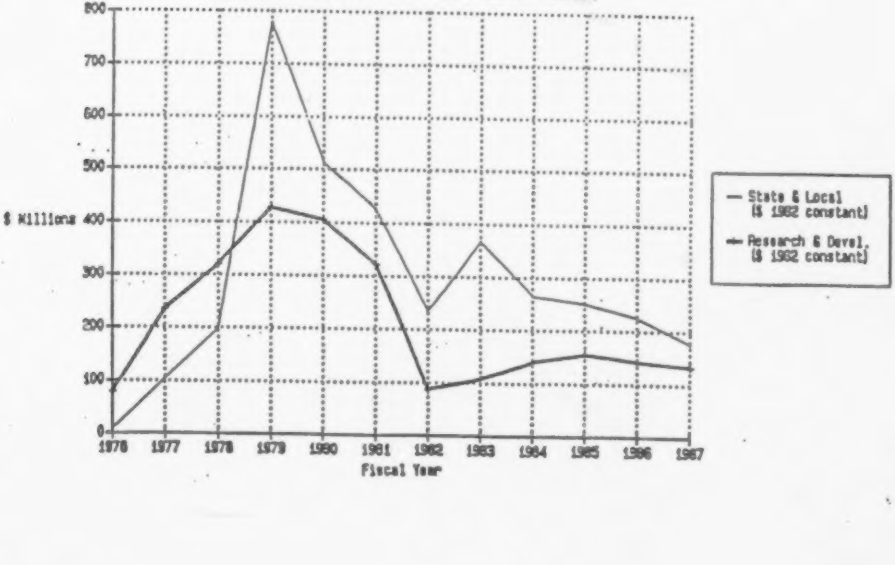
CONCLUSION

We urge Congress to preserve Federal conservation programs that meet energy needs cost-effectively, reduce oil imports, improve our international competitive standing, and improve environmental quality.

DOE Energy Conservation Programs: Total Spending
($ 1982 Constant, DOE Conservation Base Table)



DOE R&D and State & Local Spending
(Source: DOE Conservation Base Table)



ENDORSING ORGANIZATIONS FOR

THE ALTERNATIVE PROPOSAL FOR THE FY88 ENERGY CONSERVATION BUDGET

Alliance to Save Energy
American Association of Retired Persons
American Council for an Energy Efficient Economy
American Institute of Architects
American Public Power Association
Consumer Energy Council of America
Consumer Federation of America
Environmental Action
Environmental Policy Institute
Federation of American Scientists
Friends of the Earth
Fund for Renewable Energy and the Environment
National Association of Energy Service Companies
National Association of Regulatory Utility Commissioners
National Association of State Energy Officials
National Association of State Utility Consumer Advocates
National Audubon Society
National Center for Appropriate Technology
National Community Action Foundation
National Consumers League
National Wildlife Federation
Natural Resources Defense Council
Sierra Club
United Methodist Church - Board of Church and Society
U.S. Public Interest Research Group
Union of Concerned Scientists

March 11, 1987

ALTERNATIVE BUDGET RECOMMENDATIONS

TO THE

U.S. DEPARTMENT OF ENERGY'S
FY 1988 BUDGET REQUEST

FOR

ENERGY CONSERVATION R&D
AND
STATE AND LOCAL ASSISTANCE PROGRAMS

MARCH 1987

INTRODUCTION

This document presents an alternative budget for FY 1988 for the Department of Energy's Energy Conservation Research and Development Program and State and Local Assistance Programs. The document contains both a summary and a more detailed description of the recommendations. The summary located on pages 1-6, provides an overview of the alternative budget along with brief program descriptions. The summary is followed by detailed descriptions of the budget and program recommendations. It is divided into five subparts -- Transportation Energy Conservation R&D, Industrial Energy Conservation R&D, Buildings and Community Systems R&D, Multi-Sector Energy Conservation R&D, and State and Local Assistance Programs. The descriptions include summary charts for each program area, subprogram summaries and a description of several new initiatives (in the R&D programs only).

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

SUMMARY OF ESTIMATES BY APPROPRIATION BY MAJOR ACTIVITY
(dollars in thousands)

ENERGY CONSERVATION

ENERGY CONSERVATION R&D	FY 1980 Actual	FY 1986 Actual	FY 1987 Appropriation	FY 1988 Alternative	FY 1988 Request	Alternative vs. FY 1987
Transportation	$109,500	$57,457	$56,055	$55,000	$22,409	-$ 1,055
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New Initiatives				5,800		+ 5,800
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New Initiatives				9,250		+ 9,250
Multi-Sector	77,800	35,922	28,304	31,000	20,406	+ 2,696
New Initiatives				2,000		+ 2,000
Facilities	N/A	9,830	10,000	-----	-----	- 10,000
Cooperative Venture Research and Development Pools	N/A	-----	-----	5,000	5,000	+ 5,000
Policy and Management	N/A	1,726	1,862	1,662	1,662	- 200
Sub-Total, Conservation R&D	$343,800	$173,505	$161,697	$192,137	$80,090	+$30,440
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Institutional Conservation Program (Schools & Hospitals)	$143,800	$ 44,888	$ 25,170*	$ 40,050	$ 0	+ $14,880
State Energy Conservation Program (EPCA Grants)	37,800	17,903	9,400*	15,750	0	+ 6,350
Energy Extension Service	25,000	7,300	3,970*	6,750	0	+ 2,780
Weatherization Assistance Program	199,000	182,084	161,460*	162,450	0	+ 990
Territories Assistance	N/A	476	0	500	0	+ 500
Program Direction	N/A	9,745	13,500	13,500	6,000	-0-
Other	26,200	N/A	N/A	N/A	N/A	N/A
Sub-Total, State and Local Assistance Programs	$431,800	$262,396	$213,500	$239,000	6,000	+ $25,500
TOTAL, Conservation	$775,600	$435,901	$375,197	$431,137	$86,090	+ $55,940

* Under the terms of the Omnibus Reconciliation Act of 1986, and a determination by the DOE Office of Hearings and Appeals, $134 million of FY 1987 funding will be derived from the oil overcharge escrow account. An additional $66 million was appropriated for FY 1987, and is available pending an Administration recision request.

AN ALTERNATIVE PROPOSAL FOR THE FY88 ENERGY CONSERVATION BUDGET
SUMMARY

Energy conservation is the fastest growing energy resource in the U.S. economy; energy efficiency improvements over the past decade have reduced America's energy bills an estimated $100-$150 billion. The Alternative Budget for Energy Conservation reflects a thoughtful and detailed assessment that balances our nation's energy needs with federal budget constraints. Energy conservation can make a significant contribution to the underlying goal of reduced Federal deficits by easing pressure on capital markets, and consequently, freeing up funds for productive investments and lowering inflation rates.

Despite requests for significant budget cuts by the Department of Energy (DOE), Congress has restored funding for essential conservation programs over the last seven years. Federal support for energy conservation is vital to ensure an efficient economy, reduce dependence on unstable oil imports, improve international competitiveness for American industry, and improve environmental quality.

The Department of Energy's proposed FY88 Budget would cut Federal conservation programs 77% below FY87 appropriation levels from $375.2 to $86.0 million. State and Local Assistance programs would be reduced from $213.5 million to $6.0 million. Conservation Research and Development ($&D) program funds face a 50% reduction from $161.7 million to $80.1 million. Unfortunately, funding for Federal conservation programs has comprised an increasingly smaller percentage of an increasingly larger DOE energy budget, e.g., conservation R&D represents merely 3% of DOE's proposed $3 billion energy R&D budget.

The Alternative Budget for Energy Conservation proposes a total of $431.1 million for Federal energy conservation programs, a 15% increase above FY87 appropriations. Conservation R&D would receive $192.1 million, while State and Local Assistance programs would receive $239.0 million.

The alternative budget for conservation R&D includes a request for approximately $20.25 million in new R&D initiatives, including research for such technologies as fluorescent lamps that emit twice as much light as conventional fluorescents and advanced production processes for ceramic engine parts. These new initiatives focus on emerging energy efficiency technologies that offer enormous potential for commercial applications. Continued advances in energy-saving technologies can play a key role in assuring the competitiveness of U.S. industry in world markets.

The alternative budget for State and Local Assistance programs budget reflects minimal funding levels necessary to carry out a broad range of essential and innovative energy efficiency programs in all sectors of the economy. While states are currently receiving monies from the Oil Overcharge Restitution Fund, these are short-term funds intended to supplement rather than supplant Federal appropriations. While current program needs greatly exceed our alternative budget request, the alternative request ensures that every state will be able to maintain minimum funding levels for each of the four state and local programs.

BACKGROUND:
ESTABLISHING FEDERAL ENERGY PRIORITIES

Despite Congressional initiatives to restore conservation funding, Federal conservation funds were reduced from $775.6 million in 1980 to $375.2 million in 1987, a 52% decrease. Over the same time period, Appropriations for R&D have been reduced 53% from $343.8 million to $161.7 million, while state and local programs have been cut 51%. (See graphs on page 6.)

Federal energy dollars should be appropriated based upon their potential for meeting importance national needs. We recommend that DOE energy programs be evaluated according to the following criteria: cost-effectiveness (return on federal tax dollars), impact on oil imports, effect on international competitiveness, and environmental quality.

* **Meeting energy needs cost-Effectively** - Energy conservation has already made a significant contribution toward reducing our national energy bill, and the potential for additional cost-effectiveness conservation investments is enormous. The Department of Energy's FY88 Energy Conservation Multi-Year Plan reports that reductions in energy intensity (energy efficiency improvements) have accounted for approximately 20 quads (quadrillion Btu's) of energy savings through 1984, valued at more that $100 billion annually. Numerous studies suggest that the U.S. could reduce its present annual energy bill from $430 billion to $300 billion or less through the use of existing and new energy conservation technologies and measures.

* **Reducing Oil Imports** - Energy conservation can reduce oil imports and stretch the United States' diminishing domestic oil supplies. U.S. dependence on foreign oil has surged 22 percent in the last year alone, while imports from Persian Gulf countries have doubled during this same time period. Our energy position would look even worse without the significant strides in energy conservation that have been made over the last decade. The U.S. would now be consuming an additional 1.5 million barrels of oil per day - equivalent to the oil production of the entire state of Alaska - were it not for improvements in the fuel efficiency of the U.S. automobile fleet. Today's oil imports could be entirely displaced by investing in low-cost efficiency improvements in America's buildings and vehicle fleet.

* **Improving America's International Competitiveness** - Continued advances in energy-saving technology can play a key role in assuring the competitiveness of U.S. industry in the world market. Over the past decade, American automakers lost one-fourth of the global market to fuel-efficient Japanese cars. We are now witnessing the same challenge to our domestic and global market shares from foreign competitors in lighting, air conditioning, motors, appliances, manufacturing equipment, and industrial processes. Unfortunately, as the President's Commission on Industrial Competitiveness Report noted, American has recently lost global market shares in 7 out of 10 high technology market areas, despite leadership in developing high technology products. Energy efficiency R&D can reverse this trend and insure against a further erosion of competitiveness.

* **Improving Environmental Quality** - Energy conservation reduces energy use, and thus, decreases environmental harm resulting from the exploration, production, transportation, and consumption of energy. A 1983 National Science Foundation report concluded that energy conservation provides the most important opportunity to ameliorate carbon dioxide accumulation, the greenhouse effect, which is caused primarily by the burning of fossil fuels. Energy conservation can also play a significant role in reducing acid rain emissions, thermal and solid waste, and nuclear waste.

Energy conservation receives high marks in meeting each of these national goals, and therefore, funding for essential R&D and State/Local Assistance programs needs to be restored.

RESEARCH AND DEVELOPMENT PROGRAMS

MAJOR PROGRAM AREAS OF THE ENERGY CONSERVATION BUDGET

New R&D Initiatives - America's competitiveness can be enhanced through bold, new and innovative energy efficiency R&D programs to augment the lean research currently in place. Under the buildings and Community Systems Program, new initiatives include $2 million for a cooperative private/federal effort to create technologically advanced efficiency of small appliances (such as refrigerators, freezers, and heat pumps). Under the Industry R&D program, new initiatives include $3 million to establish a joint government/private sector venture to improve productivity in selected key industries and $1 million for improved sensors and controls to improve process efficiency. New transportation R&D initiatives include $500,000 for continuously-variable transmissions and $500,000 to examine advanced production processes for ceramics components. **New Initiatives Request: $20.25 million.**

Buildings and Community Systems - This program is designed to achieve a cost-effective level of energy efficiency in the nations buildings. The Buildings subprogram supports research to: determine how buildings use energy; develop new technologies for building equipment and components (e.g. heat pumps, windows, and lighting); prepare better building design tools, standards and guidelines; improve the energy efficiency of existing buildings; and to improve indoor air quality. The Community Systems subprogram develops new technologies and techniques to improve energy efficiency and management at the community level, such as district heating and cooling systems. By accelerating the commercialization of new technologies, buildings and community systems "R&D provides enormous savings to the nation. For instance, a one-time Federal investment of $5 million in the development of more efficient lighting controls (solid-state ballasts) and windows that reflect heat (low-emissivity windows) is projected to save users $36 billion - a return on Federal investment dollars of 7000 to 1.
Alternative request: $52.0 million.

Industrial - DOE's Industrial conservation program advances energy efficiency for many U.S. industries including chemicals, petroleum, metals, pulp and paper, food, textiles, and machinery. The competitiveness of many industries is directly tied to energy consumption because many of America's languishing industries are energy intensive. The Industrial R&D program emphasizes cooperative governemnt/industry efforts to identify technological needs for energy conservation and high priority projects that are not being pursued by the private sector. The program has been very successful in developing technologies and systems that are now commercially available or just entering the marketplace. For example, an R&D project, developed in conjunction with a Massachusetts firm produced the first U.S. low speed diesel cogeneration system. This system has been installed in a New Jersey pharmaceutical plant and will save the firm $9 million a year.
Alternative request: $42.3 million.

Multi-Sector - This program conducts basic research applicable to all economic sectors in the areas of combustion and thermal sciences, materials, biological and non-biological chemical conversion (such as ethanol production), and tribology (the study of friction, wear, and lubrication). In addition, the program promotes the development of promising technologies that may not otherwise be commercialized without Federal funding. The Multi-sector budget also includes support for the National Appropriate Technology Assistance Service (NATAS), which provides technical assistance to individual homeowners, small business owners, and others.
Alternative request: $33.0 million.

Transportation - The Transportation program is designed to develop advanced technologies for automobiles and light trucks, advanced battery designs for electric vehicles, and technological options that enhance fuel flexibility for non-petroleum fuels, such as methanol. Current research projects include the development of gas turbine engines with potentially greater fuel efficiencies than conventional engines. Extensive research is also geared toward the development of structural temperatures. DOE supports research through cost sharing arrangements with industry and research institutions, whose contributions range from 20-50%.
Alternative request: $58.2 million.

STATE AND LOCAL ASSISTANCE PROGRAMS

Weatherization Assistance Program (WAP) - WAP was expressly developed to improve the energy efficiency of low-income households, particularly those of the elderly and handicapped, and to reduce their energy costs. National surveys have concluded that an average WAP expenditure of $1,100 per dwelling reduces annual household energy bills an average of 10-20%, stretching household budgets for other goods and services. While it is estimated that approximately 17.6 million households are eligible to receive assistance under WAP, only three million low-income residences have been weatherized as of 1986. A modest goal of completing the eligible single-family buildings and priority multi-family buildings would cost approximately $7.5 billion.
Alternative request: $162.5 million.

Institutional Conservation Programs (ICP) - Also known as the Schools and Hospitals program, ICP was established to encourage energy conservation initiatives in public and non-profit institutional buildings where energy consumption represents a significant percentage of operating budgets. Through FY86, the program has awarded 20,000 grants for energy conservation projects in over 57,000 schools and hospital buildings. For example, an Illinois hospital is projected to cut 50% of its natural gas and 10% of its electrical consumption because of a $630,000 matching ICP grant. Between 1980-1984, ICP grantees saved its recipients an average of 13% of their annual energy bill, with a cumulative energy savings totaling approximately 34.5 million barrels of oil equivalent.
Alternative request: $40.0 million.

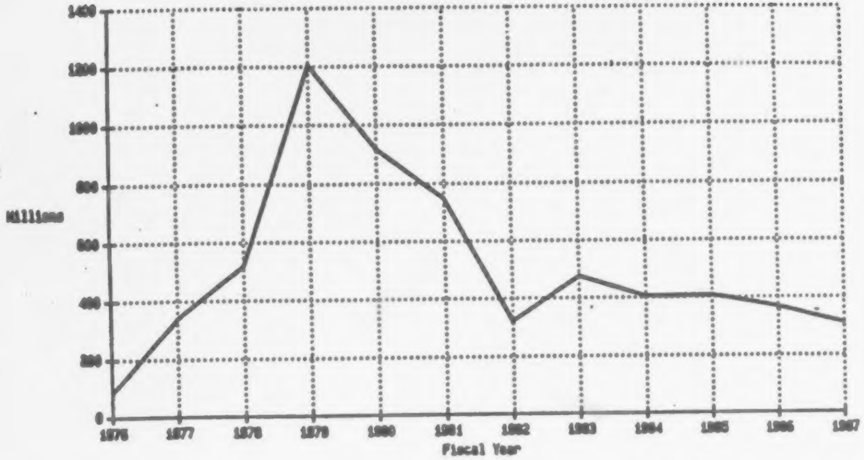
State Energy Conservation Programs (SECP) - SECP supports innovative energy efficiency programs for all sectors of the economy to help each state meet localized energy needs, while also providing substantive benefits to local economies. For instance, the Massachusetts Office of Energy Resources contracts with private engineers to help manufactures identify cost-effective conservation opportunities. The Alaska Department of Community and Regional Affairs developed an energy mortgage valuation program. This encourages the construction of more efficient homes by rewarding buyers with 2% credit on the debt to income ratio. The New York State Energy Office developed a below-market interest rate loan program to finance energy efficiency improvements for small industrial and commercial firms, not-for-profit organizations and owners of multi-family dwellings. Cumulative energy savings from SECO activities totaled approximately 670.7 million barrels of oil equivalent between 1977 and 1983.
Alternative request: $15.75 million.

Energy Extension Service (EES) - EES provides information and technical assistance for small businesses, local governments and homeowners on effective and productive energy conservation and renewable energy options. EES programs are diverse and innovative. For instance, the Washington Energy Extension Service has developed an irrigation system audit guide and a computer program on water scheduling to help farmers reduce irrigation energy costs. The Maryland Small Town Energy Education Program has assisted 30 towns in designing cost-effective conservation strategies by providing free energy audits of their municipal buildings and water treatment plants and consultations on street lighting efficiency improvements. EES programs leverage federal dollars with local funds to achieve maximum conservation benefits.
Alternative request: $6.75 million.

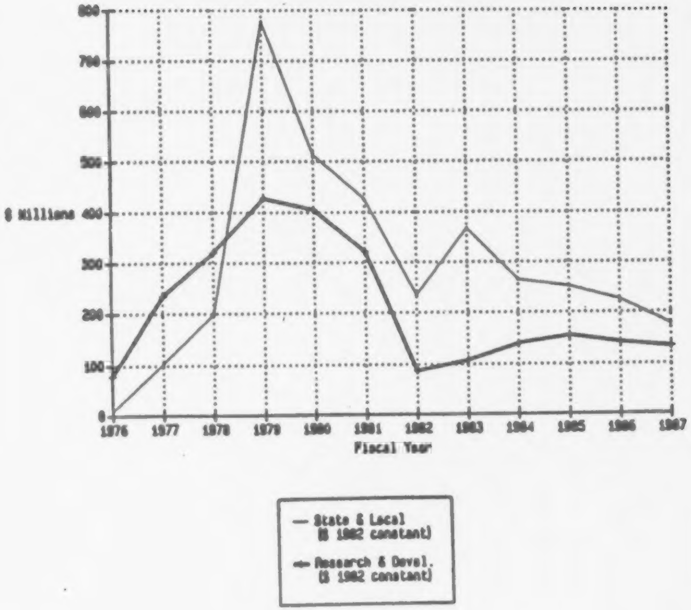
CONCLUSION

We urge Congress to preserve Federal conservation programs that meet energy needs cost-effectively, reduce oil imports, improve our international competitive standing, and improve environmental quality.

DOE Energy Conservation Programs: Total Spending
($ 1982 Constant, DOE Conservation Base Table)



DOE R&D and State & Local Spending
(Source: DOE Conservation Base Table)



TRANSPORTATION PROGRAMS

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

TRANSPORTATION ENERGY CONSERVATION
(dollars in thousands)

LEAD TABLE

	FY 1986 Actual	FY 1987 Appropriation	FY 1988 Alternative	FY 1988 Request	Alternative vs. FY 1987
1.0 Vehicle Propulsion Research and Development	$32,624	$23,500	$20,500	$ 7,370	-$ 3,000
2.0 Alternative Fuels Utilization	1,423	1,260	2,200	1,100	+ 940
3.0 Electric and Hybrid Vehicle Research and Development	8,709	13,400	13,400	3,400	-0-
4.0 Transportation Systems Utilization	897	700	1,100	400	+ 400
5.0 Advanced Materials Development	8,746	13,000	13,000	6,657	-0-
6.0 Capital Equipment for Advanced Materials Development ..	0	1,000	500	0	- 500
7.0 High Temperature Materials Lab	295	1,000	2,000	2,000	+ 1,000
8.0 Construction for High Temperature Materials Lab	2,574	0	0	0	-0-
9.0 Program Direction	2.189	2,195	2,300	1,482	+ 105
10.0 New Initiatives	-----	-----	3,200	0	+ 3,200
Total, Transportation Energy Conservation	$57,457	$56,055	$58,200	$22,409	+$ 2,145
Staffing, Total FTE	30	36	36	22	+ 14

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

U.S. DEPARTMENT OF ENERGY

TRANSPORTATION ENERGY CONSERVATION

OVERVIEW

Transportation used approximately 19.9 quads of energy in 1985, primarily (97%) oil. This represents about 10 million barrels per day, 63% of all petroleum consumed in the U.S. or 107% of U.S. petroleum production.

Projections from DOE indicate continued growth in petroleum consumption in the future, even though the energy efficiency of autos has increased. Average fuel economy of all cars on the road was 17.5 mpg in 1985 vs 13.1 mpg in 1973 and will continue to improve as older vehicles are replaced with newer more efficient models. While other sectors have been able to switch to alternative fuels, the effort to use alternative fuels has had more limited success in the transportation sector. It is in the national interest, therefore, to increase energy efficiency and provide alternative technologies for the transportation sector.

The goals of the DOE Transportation Program are to develop advanced automotive engines that are 30% more efficient than comparable vehicles now in use; to develop heavy duty diesel truck engines capable of efficiency improvements of 30-35% over 1982 performance; and provide technological options that enhance fuel flexibility such as electric and hybrid vehicles and alternative fuels.

Transportation research is conducted under the aegis of multi-year plans developed in conjunction with industry, and includes some mandated information programs, such as distribution of the gas mileage guides. It focuses on the major consumers of petroleum (auto and trucks) and on the second largest petroleum consumers (heavy trucks and buses). Much of its work is conducted through cost-shared agreements with industry. Contributions from industrial participants and research institutions range from 20% to 50%.

A significant portion of the budget is used to develop and evaluate ceramics and other high temperature materials because of their critical role on the successful introduction of advanced heat engines. In addition, ceramics, a new technology with promise for providing advances in the aerospace industry, high temperature industrial processes, and vehicle engines, can play a major role in improving industrial competitiveness. Market estimates indicate the potential for a $15 billion market for ceramics by 2000. R&D in these areas can assist U.S. industry in developing ceramics to compete for the new markets.

Program Accomplishments

Research projects in the Transportation Program often require many years before reaching fruition, but several recent accomplishments are noteworthy.

- Two gas turbine engine designs, with the potential to improve energy efficiency out by 30% over conventional automobile engines have been produced and tested. These engines are used for testing ceramic rotors and components that must withstand temperatures near

2500°F to attain the high efficiency operation. By 1986, selected stationery ceramic parts were operating successfully in a test at 2500°F for the first time.

- In the area of materials and processing, R&D resulted in a ceramic composite reinforced by silicon "whiskers" with greatly improved strength and toughness.
- The Heavy Duty Transport Subprogram has fabricated first generation ceramic coated piston rings for adiabatic diesel engine evaluation.
- The Alternative Fuels Utilization Subprogram is evaluating the performance of government vehicles that use methanol fuel to determine the feasibility of substituting methanol vehicles for those now using gasoline.
- Battery research conducted under the Electric and Hybrid Vehicle Subprogram resulted in modules and battery subsystem design for the advanced lead acid, zinc/bromine, and sodium/sulphur technologies.
- An advanced single shaft ac power train by Ford Motor Co. was developed, installed in a test bed vehicle, and associated dynamometer testing with zinc/bromine batteries was completed.

FY 1988 ALTERNATIVE FUNDING RECOMMENDATIONS FOR TRANSPORTATION PROGRAMS - $58,200,000

Funding of $58,200,000 is required to continue research on promising transportation technologies, and new initiatives. Recommended levels are outlined in the specific subprogram areas that follow.

1.0 VEHICLE PROPULSION R&D

This subprogram conducts research on advanced heat engines including automotive gas turbine and heavy duty transport engines. Consistent with the Automotive Propulsion Research and Development Act of 1978, DOE has focused its R&D on improving energy efficiency by 30% over conventional engines while meeting noise requirements and operating on a variety of fuels. Automotive gas turbine engines that operate at 2300-2500°F require development of reliable structural ceramic components, small efficient turbo machinery, and low emission combustors. Funding in FY 1988 would continue testing and evaluation of ceramic components in two gas turbine engine rigs. The Heavy Duty Transport Subprogram is focused on the uncooled adiabatic, minimum friction diesel engine that could replace conventional diesel engines in long haul trucks. Engine R&D should continue at near FY 1987 funding levels to develop high mechanical and thermal stress resistant materials, high temperature friction and wear (tribology) concepts, dry film lubricants, and to perform piston and cylinder friction analysis. The recommended funding level for this subprogram is $20,500,000.

2.0 ALTERNATIVE FUELS UTILIZATION

This subprogram conducts R&D on several promising fuels to provide an alternative to petroleum by using domestic resources such as fuels derived from coal, oil shale, natural gas and biomass. These fuels would enhance national security by decreasing dependence on imported oil as well as enhancing our capability to meet emission standards (e.g., methane in diesels to meet particulate standards). FY 1988 R&D in methane, synthetic fuels and alcohols should be funded at $2,200,000.

3.0 ELECTRIC AND HYBRID VEHICLE R&D

This subprogram conducts electric and hybrid vehicle research that will lead to the production and market introduction of electric vehicles. Because electricity is generated by many different fuels (coal, hydro or nuclear), the use of electric vehicles would substitute more abundant sources of energy for petroleum-based fuels. Technology needs include the development of batteries with more power, longer life, and lower cost. Propulsion systems needs include low cost and reliable high power transistors, low-cost, permanent magnet ac motors and inverters, and controllers. Longer range R&D projects such as fuel cells for automotive application merit continued support.

The recommended level for Electric and Hybrid Vehicles is $13,400,000 to continue Electric Vehicle Battery R&D, Electric Vehicle Propulsion Systems, and Testing and Evaluation.

4.0 TRANSPORTATION SYSTEMS UTILIZATION

This subprogram analyzes current and future transportation demand and consumption patterns and is responsible for the gas mileage guides. Continued funding for FY 1988 of $1,100,000 is recommended.

5.0 ADVANCED MATERIALS DEVELOPMENT

This subprogram conducts R&D to develop an industrial technology base in structural ceramics, ceramic composites, and coatings for high temperature propulsion systems. These materials offer the potential for using abundant U.S. resources instead of strategic materials for numerous high temperature applications. Because almost all high performance energy conversion systems operate at high temperatures in corrosive environments, several basic problems must be solved before energy efficiencies can be realized. The development of ceramics for use in these systems requires research in the areas of ceramic materials, design, processing, and durability prediction. Ceramics have major potential advantages in high temperatures because of their strength and corrosion resistance, but their brittleness creates problems for engine design. Consequently, R&D is needed to continue materials properties research as well as develop international standards and certification procedures to enhance reliability of these materials. A funding level of $13,000,000 is recommended for the R&D in Advanced Materials Development. Further, $500,000 is recommended for capital equipment to support Advanced Materials Development.

7.0 HIGH TEMPERATURE MATERIALS LAB

The High Temperature Materials Laboratory (HTML) is being constructed at Oak Ridge National Laboratory to support the advanced materials research of the Transportation Program, other DOE offices, government agencies, universities and industry. The HTML will begin operation as a user national facility in 1987 with equipment and instrumentation for correlating the micro-structure and micro-chemistry of materials with their physical and mechanical properties. Funding of $2,000,000 is recommended to support the scientific staff of the HTML.

9.0 PROGRAM DIRECTION

Funding of $2,300,000 is recommended to provide for 36 FTEs.

10.0 NEW INITIATIVES

Funding of $5,800,000 is recommended for five new initiatives.

CONTINUOUSLY VARIABLE TRANSMISSIONS (CVT) ($500,000)

Although considerable federal government and industry R&D has been performed on CVT's, none of the systems investigated have been adopted by American Manufacturers, although Subaru in Japan is now selling a car equipped with a CVT. One reason is that improved conventional engine efficiency with a CVT is not judged to be a reasonable trade-off because of the additional complexity and unknown reliability involved. This is particularly true with the forecasted improvements in modern, digitally-controlled automatic transmissions. However, there are advanced engine systems applications where CVTs will be necessary or highly advantageous. For instance, any single shaft automotive gas turbine will require a CVT, and an adiabatic diesel with a CVT would theoretically be operated over any driving cycle at maximum waste heat utilization. Funds will be used in the Vehicle Propulsion R&D subprogram to identify further R&D required to expand the technology base for future applications.

ADVANCED PRODUCTION CERAMIC PROCESSES ($500,000)

Funding will be used to sponsor a study by the U.S. Advanced Ceramics Association (USACA) to determine the feasibility of establishing a collaborative facility for advanced ceramic manufacturing and engineering. Recent initiatives that have been outlined for centers in several regions of the country, including the Southeast, Midwest and California, indicate the significant interest that ceramics engineering is stimulating. The USACA study could assess the role such a center could play in the overall development of the ceramics industry and identify alternative approaches.

NATIONAL ACADEMY OF SCIENCES STUDY ON BARRIERS TO ALTERNATIVE FUEL USE ($500,000)

Funding will be used to sponsor a study by the National Academy of Sciences to study the transition from petroleum-based vehicles to non-petroleum, fuel flexible or alternate fuel vehicles. The study will examine institutional, economic and technical barriers and identify policy and research and development needs (e.g., cold start problems with methanol, potential use of natural gas/methane in heavy duty diesel engines) to expedite the transition.

PROTOTYPE OF PASSENGER CAR ADIABATIC DIESEL ENGINE ($1,500,000)

To date, adiabatic engine research has focused primarily on heavy duty vehicles, but the application of adiabatic technology for light duty vehicles has potential. In normal light duty driving cycles, the partial load operations have a significant affect on the application of adiabatic diesel technology to passenger car/light duty truck market. In addition to most efficient design for engine operating and emission parameters, the entire system for waste heat utilization must be radically different from the heavy duty truck operational mode. A preliminary study for light duty applications was conducted by Cummins Engine Company several years ago, but any follow-on work was put off until some of the basic system, heat transfer, materials, and tribology technology areas were better understood. All of these areas are now entering the component design and evaluation stages. Consequently, funding will be used to initiate integration for light duty adiabatic engines.

ADVANCED WINDOW GLAZINGS FOR PASSENGER VEHICLES ($200,000)

Recent styling changes in automobiles have increased the use of glass, which has resulted in greater internal heat gain from sunlight. In turn, automobile air conditioners are used more to compensate for the additional heat gain. Automobile fuel economy is consequently reduced, especially in hot climates. Recent advances in glazings indicate the significant potential for control heat gain in passenger vehicles. Working with key industrial partners, the Transportation Program will develop and validate a simulation tool to predict auto performance with variable glazing selections. To the extent feasible, related materials research will also be conducted on appropriate glazing candidates that offer potential energy efficiency improvements.

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

TRANSPORTATION ENERGY CONSERVATION
(dollars in thousands)

SUMMARY OF KEY ACTIVITIES

1.0 VEHICLE PROPULSION RESEARCH AND DEVELOPMENT

Program Activity	FY 1986	FY 1987	DOE Request FY 1988	Alternative FY 1988	Alternative vs. FY 1987
1.1 Auto Gas Turbine	$14,283	$10,000	$ 4,000	$15,000	+$ 5,000
1.2 Stirling Engine	14,283	8,000	0	0	- 8,000
1.3 H.D. Transport Diesel	2,858	4,500	2,900	4,500	-0-
1.4 Technology Assessment	1,200	1,000	470	1,000	-0-
Sub-Total, Vehicle Propulsion R&D	$32,624	$23,500	$ 7,370	$20,500	-$ 3,000
2.0 ALTERNATIVE FUELS	$ 1,423	$ 1,260	$ 1,100	$ 2,200	+$ 940
3.0 ELECTRIC & HYBRID VEHICLE RESEARCH					
3.1 Battery Research and Development	$ 3,622	$ 5,250	$ 1,800	$ 4,300	-$ 950
3.2 Electric Vehicle Propulsion	3,190	5,750	1,600	6,300	+ 550
3.3 Test and Evaluation	1,784	2,400	0	2,800	+ 400
3.4 Technology Assessment	113	0	0	0	-0-
Sub-Total, Electric and Hybrid	$ 8,709	$13,400	$ 3,400	$13,400	-0-

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

TRANSPORTATION ENERGY CONSERVATION
(dollars in thousands)

SUMMARY OF KEY ACTIVITIES

Program Activity	FY 1986	FY 1987	DOE Request FY 1988	Alternative FY 1988	Alternative vs. FY 1987
4.0 TRANSPORTATION SYSTEMS UTILIZATION	$ 897	$ 700	$ 400	$ 1,100	+$ 400
5.0 ADVANCED MATERIALS DEVELOPMENT	8,746	13,000	6,657	13,000	-0-
6.0 CAPITAL EQUIPMENT FOR ADVANCED MATERIALS DEVELOPMENT	0	1,000	0	500	- 500
7.0 HIGH TEMPERATURE MATERIALS LABORATORY	295	1,000	2,000	2,000	+ 1,000
8.0 CONSTRUCTION FOR HIGH TEMPERATURE MATERIALS LABORATORY	2,574	0	0	0	-0-
9.0 PROGRAM DIRECTION	2,189	2,195	1,482	2,300	+ 105
10.0 NEW INITIATIVES	-----	-----	0	3,200	+ 3,200
TOTAL, Transportation Energy Conservation	$57,457	$56,055	$22,409	$58,200	+$ 2,145

INDUSTRIAL PROGRAMS

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

INDUSTRIAL ENERGY CONSERVATION
(dollars in thousands)

LEAD TABLE

	FY 1986 Actual	FY 1987 Appropriation	FY 1988 Alternative	FY 1988 Request	Alternative vs. FY 1987
1.0 Waste Energy Reduction	$11,432	$12,256	$12,600	$ 7,821	+ $ 344
2.0 Industrial Process Efficiency	20,003	13,300	13,900	4,600	+ 600
3.0 Industrial Cogeneration	4,478	5,000	5,000	1,500	-0-
4.0 Implementation and Deployment	2,732	2,400	2,900	500	+ 500
5.0 Program Direction	2,063	2,070	2,100	1,614	+ 30
6.0 Capital Equipment	-----	-----	-----	-----	-----
7.0 New Initiatives	-----	-----	5,800	-0-	+ 5,800
Total, Industrial Energy Conservation.	$40,708	$35,026	$42,300	$16,035	+ $ 7,274
Staffing, Total FTE	27	35	35	26	+ 9

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

INDUSTRIAL ENERGY CONSERVATION

OVERVIEW

The industrial sector consumed approximately 27.0 quads of energy in 1985, 36.5% of total U.S. consumption. This included 7.7 quads of oil (approx. 3.9 million barrels per day (MBPD)). Continued commitment to industrial conservation projects is needed not only to reduce energy consumption and threats to our national security, but because such R&D activities may increase U.S. industries' international competitiveness. Competitiveness is directly tied to energy consumption since energy is a significant production cost in many of the hardest hit industries contributing to the largest trade deficit in history. The following are some examples of the trade deficits in the industrial sector -- $3 billion in glass and construction, $3 to $4 billion in food products, $3 to $4 billion in paper products, $16 to $17 billion in machinery, $17 to $18 billion in steel, aluminum and copper, and $18 to $19 billion in textiles and apparel. Energy intensive industries in other countries often use significantly more energy efficient processes than their U.S. counterparts. While not the only factor in industrial competitiveness, energy efficiency represents a prime target for improvement.

The DOE Industrial Energy Conservation Program advances energy efficiency and productivity for many U.S. industries including chemicals, petroleum, metals, pulp and paper, food, textiles, and machinery as well as non-manufacturing activities. The program conducts cost-shared research in industrial processes, advanced energy conservation equipment, innovative multi-fuel technologies for industrial applications and technology transfer. It with industry to identify high priority energy conservation projects not being pursued by the private sector. DOE then negotiates cost-shared contracts with private industry or appropriate universities and laboratories to carry out the research and development activities until the new technologies have been proven to be both technologically and economically viable.

Program Accomplishments

A long lead time is necessary to develop major industrial innovations. However, DOE's Industrial Energy Conservation Program has successfully developed technologies and systems that are now available or just entering the marketplace. For example, working with Allied Signal Co., DOE developed a membrane system that is an energy efficient method of separating light hydrocarbons from heavy oils, thus replacing distillation in petroleum refining. Another membrane system developed by Bend Research in Oregon separates liquids, thereby reducing the energy needed for evaporation in food processing. Ceramic heat exchangers that recover heat from exhaust temperatures up to 2000°F have been developed in cost-shared projects with GTE, Babcock & Wilcox, and Airesearch. The Babcock & Wilcox unit is used at a steel mill soaking pit in Pennsylvania. These units should have many different applications and will save 40-50% of fuel use.

An advanced fluidized bed boiler developed by DOE and Aerojet represents another type of heat recovery system that uses fouling exhausts and can produce steam or hot water to recover otherwise wasted heat. This system is now operating in 36 installations around the world. A system for oxygen production developed by DOE and Air Products and Chemicals (Allentown, Pennsylvania) in a cost-shared project produces oxygen using 40% less energy than current cryogenic processes. This chemical air separation process uses a molten mixture of alkali nitrates and nitrites to produce oxygen in a reversible chemical reaction.

DOE and the Thermo Electron Co. of Massachusetts produced the first low speed diesel cogeneration system in the U.S. and it is now operating at the Hoffman La Roche pharmaceutical plant in New Jersey. This cogeneration system will provide 23 megawatts of electricity and 165,000 pounds of process steam, saving $9 million a year. This system is being evaluated for use at four other sites. Foundry technology has benefitted from DOE funded advances in slot forge furnaces and cupola burners.

Manufacturing is not the only activity that has benefitted from new energy efficiencies. Textile production has been improved by using foam to replace water in textile processing. Developed by United Merchants in South Carolina, this system saves energy and doubles output because it replaces slower hot water dyeing methods with faster foam finishing for textiles and carpets. Agricultural applications include development of new irrigation and fertilizer processing systems. Technical assistance provided by the Energy Analysis and Diagnostic Centers utilizing university engineering facilities across the country, have provided audit and energy analyses for 1,456 firms through 1985.

FY 1988 ALTERNATIVE FUNDING RECOMMENDATIONS FOR INDUSTRIAL PROGRAMS - $42,300,000

Funding of $42,300,000 is needed to achieve potential energy and productivity benefits for innovative and long term industrial projects still under investigation, and for program direction and several new initiatives.

1.0 WASTE ENERGY REDUCTION

The Waste Energy Reduction Subprogram conducts R&D on waste heat recovery, combustion improvements, and industrial utilization. A total of $12,600,000 should be provided to continue development of oxygen-enriched combustion processes and furnace controls. This includes coal combustors to retrofit or replace industrial boilers. R&D should continue on heat pumps and advanced heat exchangers and recuperators that can operate in the fouling, corrosive and hot (with temperatures ranging from 300°F to 2200°F) environment of industrial waste streams to recover waste heat. The DOE should also continue work on the Brayton cycle heat pump and continue evaluating waste gases for potential energy conservation. It should also test methods of converting liquid/solid wastes to fuel from papermill wastes, tires, synthetic textiles, and plastic wastes (including wastewater bioprocess modelling), and using ceramic membranes to recover chemicals from liquid waste streams. Evaluation of waste gases for energy conservation should also be continued. The recommended level for FY 1988 is $12,600,000.

2.0 INDUSTRIAL PROCESS EFFICIENCY

The goal of the Industrial Process Efficiency Subprogram is to improve the efficiency of specific manufacturing processes, particularly in energy-intensive industries. A total of $13,900,000 should be provided for this program. This funding would continue advances in process electrolysis to produce aluminum more efficiently by analyzing the interaction of the materials involved (electrolyte; electrodes, cell walls, etc.) Continuation of near net shape casting and direct reduction of iron ore (known as the Steel Initiative) will not only significantly lower energy consumption, but revolutionize steel making. Sensor R&D for on-site analysis of molten steel and paper mill processes should be continued. Developing sensors that can operate in harsh industrial processes (withstanding corrosion, extreme temperatures and pressure) will allow more precise operational controls with resulting improvements in energy efficiency, productivity, and product quality.

Since a critical step in many industrial processes is the separation/concentration of one or more chemical components in a solution or mixture that uses energy for evaporation or distillation, there is a need to develop less energy intensive methods including membranes, freeze concentration, solvent or critical fluids extraction and advanced drying concepts. R&D funding should continue separations research for petrochemical, food, and paper processing applications including development of black liquor (a residual byproduct of pulp operations) gasifiers at pulp and paper mills. DOE should also continue research on drying and evaporation, freeze concentration and melt crystallization technology for solid/liquid separation systems, development of dry coating systems for textiles, and advanced coatings for furniture and equipment to reduce energy used for drying.

3.0 INDUSTRIAL COGENERATION

The Industrial Cogeneration Subprogram develops cogeneration technologies, either topping or bottoming systems, that are fuel flexible and provide alternatives (e.g. coal fired units) to conventional fuel use. $5,000,000 should be provided for this subprogram to continue development of a coal fired Brayton cogeneration system for use in topping cycle application. This level would also fund a sodium heat engine that could be used in chloralkali plants.

4.0 IMPLEMENTATION AND DEPLOYMENT

The Implementation and Deployment Subprogram assists small manufacturers across the country through Energy Analysis and Diagnostic Centers (EADCs). These centers, through faculty members and engineering students of participating universities provide information to improve the energy efficiency of small manufacturing facilities. $2,900,000 should be provided to continue the EADCs and other outreach and information efforts.

5.0 PROGRAM DIRECTION

Funding of $2,100,000 is recommended to provide for 35 FTEs.

7.0 NEW INITIATIVES

Funding of $5,800,000 is recommended for four new initiatives.

SENSORS AND CONTROLS FOR IMPROVED PROCESS EFFICIENCY ($1,000,000)

Funding would be used for new research and development on sensors and artificial intelligence for improved industrial process controls. The key to this activity is the expert system that combine the physical system data, process engineering knowledge and operational diagnostic experience to optimize energy supply with demand.

Such an expert system should be able to reduce the amount of purchased energy per unit of product by approximately 5 to 10%. This is achieved by decreasing downtime on paper machines, steel/glass smelters, etc.; reducing sheet breaks, and steel/glass defects on roll presses; steam and electrical load shedding; increasing boiler efficiencies, improving boiler allocation; and improving use of purchased electricity and a steadier steam header pressure.

MEMBRANE SEPARATION TECHNOLOGY ($800,000)

High temperature and pressure membranes, made from metals or ceramics, would be used to separate hydrocarbon and organic laden wastes in the organic chemicals, petroleum, laundry and dry cleaning, textiles, and solvent degreasing process streams. Research would be conducted on separation concepts for organics in wastewater with fouling solids using metal or ceramic membranes. These concepts focus beyond current state-of-the-art and provide more precise separations at the molecular level than currently possible. This would allow more efficient recovery of chemicals resulting both in productivity and energy efficiency improvements.

FEDERAL/PRIVATE CONSORTIUM FOR PULP MILL EFFICIENCY ($1,000,000)

Funding would provide increased federal participation in an industrial consortium to design, build and test a 150 ton per day black liquor gasifier in a pulp and paper mill. Since a successful laboratory test phase, private sector efforts in developing this technology have been directed toward formation of an industry consortium that would cost share the 150 ton pilot plant. If successful, a full scale production unit, funded totally ($20 million) by the private sector, would be built. Eight firms have signed up for the consortium and several others having expressed interest. These funds would add to the federal share and assure timely execution.

JOINT VENTURE FOR ADVANCED INDUSTRIAL PRODUCTIVITY ($3,000,000)

Funding of $3,000,000 is recommended for initial federal participation in a joint venture with U.S. industries for increased competitiveness. Participants within selected key industries would cooperate to improve productivity in those industries. The project would help form public corporations (funded by federal and private sources) to sponsor research and development for increased energy productivity in selected energy-intensive industries, such as textiles. Conceivably, there could be several corporations, one for each target industry. This initial funding would be for planning and establishing the corporation.

Although similar to the "venture pools" proposed by the Office of Management and Budget, this concept has some important differences e.g., the federal cost-share would not be limited to 50% but would be negotiated on a case-by-case basis; the research to be pursued would not be limited to pre-competitive phases nor long term; and the industry participation would be more flexible so as to include not only "industry" members but other interested parties as well.

The fundamental idea is to provide a means by which private industries can work together to counter foreign competition through improved energy end-use efficiency. This concept could mature--in later phases--into an industry-only self help organization.

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

INDUSTRIAL ENERGY CONSERVATION
(dollars in thousands)

SUMMARY OF KEY ACTIVITIES

1.0 WASTE ENERGY REDUCTION

Program Activity	FY 1986	FY 1987	DOE Request FY 1988	Alternative FY 1988	Alternative vs. FY 1987
1.1 Improved Combustion	$ 1,100	$ 1,300	$ 800	$ 1,000	-$ 300
1.2 Advanced High Temperature Heat Pumps	1,765	1,600	1,000	2,000	+ 400
1.3 Advanced High Temperature Recuperators	2,975	2,400	1,495	3,300	+ 900
1.4 Liquid/Gas/Solid Waste Conversion	1,200	1,400	1,340	1,800	+ 400
1.5 Utilization of Waste Gases	558	1,000	500	700	- 300
1.6 National Laboratory/Analytical Support	3,834	4,556	2,686	3,800	- 756
Sub-Total, Waste Energy Reduction	$11,432	$12,256	$7,821	$12,600	+ $ 344

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

INDUSTRIAL ENERGY CONSERVATION
(dollars in thousands)

SUMMARY OF KEY ACTIVITIES

2.0 INDUSTRIAL PROCESS EFFICIENCY

Program Activity	FY 1986	FY 1987	DOE Request FY 1988	Alternative FY 1988	Alternative vs. FY 1987
2.1 Process Electrolysis	$ 1,500	$ 1,000	$ 500	$ 1,000	-0-
2.2 Materials Processing	14,151	6,800	900	5,900	-$ 900
2.3 Sensors and Controls	2,000	2,000	1,300	2,200	+ 200
2.4 Separations Research	1,952	3,000	1,900	3,900	+ 900
2.5 Coatings	400	500	0	400	- 100
2.6 Comminution	0	0	0	500	+ 500
Sub-Total, Industrial Process Efficiency ..	$20,003	$13,300	$ 4,600	$13,900	+ $ 600

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

INDUSTRIAL ENERGY CONSERVATION
(dollars in thousands)

SUMMARY OF KEY ACTIVITIES

3.0 INDUSTRIAL COGENERATION

Program Activity	FY 1986	FY 1987	DOE Request FY 1988	Alternative FY 1988	Alternative vs. FY 1987
3.1 Advanced Topping	$ 3,378	$ 3,500	$ 800	$ 3,500	-0-
3.2 Thermal to Electric Conversion	1,100	1,000	700	1,500	+$ 500
3.3 Advanced Bottoming	0	500	0	0	- 500
Sub-Total, Industrial Cogeneration	$ 4,478	$ 5,000	$ 1,500	$ 5,000	-0-
4.0 IMPLEMENTATION AND DEPLOYMENT	$ 2,732	$ 2,400	$ 500	$ 2,900	+ 500
5.0 PROGRAM DIRECTION	2,063	2,070	1,614	2,100	+ 30
6.0 NEW INITIATIVES	-----	- ---		5,800	+ 5,800
TOTAL, Industrial Energy Conservation	$40,708	$35,026	$16,035	$42,300	+$ 7,274

BUILDINGS AND COMMUNITY SYSTEMS PROGRAM

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

BUILDINGS AND COMMUNITY SYSTEMS
(dollars in thousands)

SUMMARY OF KEY ACTIVITIES

	FY 1986 Actual	FY 1987 Appropriation	FY 1988 Alternative	FY 1988 Request	Alternative vs. FY 1987
1.0 Building Systems	$12,124	$ 8,950	$12,125	$ 3,600	+$ 3,175
2.0 Community Systems	3,813	2,900	3,900	0	+ 1,000
3.0 Technology and Consumer Products ..	10,285	9,250	11,950	4,400	+ 4,200
4.0 Analysis and Technology Transfer ..	2,594	2,000	3,600	1,000	+ 2,000
5.0 Appliance Standards	1,906	2,000	2,000	1,800	-0-
6.0 Federal Energy Management Program	1,214	950	1,000	1,000	+ 50
7.0 Residential Conservation Service ..	381	0	800	0	+ 800
8.0 Program Direction	3,639	3,650	3,650	2,500	-0-
9.0 Capital Equipment	1,906	750	1,800	278	+ 1,050
10.0 New Initiatives	-----	-----	9,250	0	+ 9,250
Total Buildings and Community Systems	$37,862	$30,450	$51,975	$14,578	+$21,525
Staffing Total FTE	71	71	71	45	+ 26

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

BUILDINGS AND COMMUNITY SYSTEMS

OVERVIEW

The Nation's buildings sector consumed approximately 27 quads of energy in 1985, 36% of total U.S. consumption. During the past decade, energy consumption in the sector has remained constant while occupied housing stock has increased by more than 15% and commercial floor space by more than 20%. Although this is an impressive gain in energy end-use efficiency, numerous studies have shown that there is significant potential for further improvements in both residential and commercial buildings. New technologies could result in new buildings that use 80% less energy than the present building stock. Similarly, retrofit technologies could significantly reduce the energy use of existing buildings. This potential for energy conservation gains offers the enhancement of the competitive position of U.S. industries in the world marketplace development and improvement of energy conservation technologies. Building energy conservation, therefore, plays a significant role in national energy policy, and is a critical element in a balanced and diverse energy resource system.

The Buildings and Community Systems (BCS) Program leads a national effort to achieve the most cost-effective, energy efficiency attainable in the buildings sector. Objectives that have been established to carry this out are:

- Development by 2010 of advanced building energy efficiency technologies that can produce annual energy savings of 10 quads ($50 billion) per year and that enhance energy source flexibility.
- Transfer of the results of energy-efficiency R&D to the private sector for commercialization.
- Identification and reduction of impediments to the adoption of building energy-efficiency technologies.
- Implementation of DOE's Congressionally mandated regulatory responsibilities for building energy efficiency in buildings.

The strategy for achieving these objectives includes three components: research, obligations for mandated programs, and the transfer of new technologies to industry.

Research is conducted to advance the scientific and technical understanding of how energy is consumed in buildings and how increased energy efficiency can be achieved while maintaining healthful indoor environments. Three research subprograms are conducted: (1) Building Systems, advancement of energy-efficient building shells; (2) Technology and Consumer Products, advancement of energy-efficient heating, cooling, lighting and other building equipment; and (3) Community Systems, advancement of cost-effective district heating and cooling and other community-based energy systems.

Three subprograms are required to be conducted: (1) Appliance Standards, the development and maintenance test procedures for determining the energy efficiency of major home appliances and, where appropriate, the establishment of minimum energy-efficiency standards for these appliances; (2) Federal Energy Management Program (FEMP), the coordination of the effort to reduce energy consumption in the Federal Sector; and (3) Residential Conservation Service, the coordinate of a voluntary effort by major utilities to encourage energy conservation in buildings.

In addition, mandated program activities are conducted in two other subprograms. The Building Systems subprogram includes support for the development and introduction of voluntary standards for new residential and commercial buildings in the private sector and mandatory standards for new Federal buildings. The Analysis and Technology Transfer subprogram conducts a Least Cost Utility Planning activity to develop analytical tools and collect data needed by the utility industry for least-cost planning initiatives.

The Analysis and Technology Transfer Subprogram disseminates research results to a wide range of interested parties and decision makers through public and private sector technology transfer mechanisms. This subprogram also provides the data and tools needed for program planning and evaluation.

FY 1988 ALTERNATIVE FUNDING RECOMMENDATION FOR BUILDINGS AND COMMUNITY SYSTEMS - $51,975,000

Funding of $51,975,000 is recommended for the seven subprograms listed in this budget, plus New Initiatives, Program Direction and Capital Equipment.

1.0 BUILDING SYSTEMS

The Building Systems Subprogram supports research to understand how energy is used in buildings and methods of improving building energy efficiency. It consists of five key activities with the development of new technologies being the major emphasis in each activity:

- Building materials research - examines the energy performance of materials for new and existing buildings and develops new materials.
- Building subsystems research - studies the energy efficiency impact of walls, roofs, foundations, fenestration, and air movement, and the effects of energy efficiency measures on indoor air quality.
- Advanced residential and commercial buildings research - studies the interactions among components and how these subsystems can be integrated to produce a more energy efficient whole building.
- Building retrofit research - focuses on the special problems associated with improving the energy performance of existing buildings.
- Standards and guidelines - implements the statutory requirement to develop voluntary energy efficiency standards for private sector buildings and mandatory standards for Federal buildings.

FY 1988 funding of $12,125,000 is recommended for this subprogram.

2.0 COMMUNITY SYSTEMS

The Community Systems Subprogram develops new technologies and techniques to improve energy use and management at the community level. It also supports research to utilize alternative energy resources, and provides technical information to help communities make energy-related decisions. This subprogram consists of two key activities: District Heating and Cooling; and Community Energy Systems Integration.

FY 1988 funding of $3,900,000 is recommended for this subprogram. These funds would be used to continue research on advanced fluids, components, and systems that improve the efficiency of district heating and cooling systems; and to help communities adopt energy-efficient technologies.

3.0 TECHNOLOGY AND CONSUMER PRODUCTS

The Technology and Consumer Products Subprogram is responsible for providing the technology to support development of more efficient building energy equipment. It supports basic engineering research that has the potential to substantially increase the efficiency of conversion of oil, gas, solid fuels, and electricity into space heating and cooling, refrigeration, and lighting. This subprogram consists of four key activities: thermally activated heat pumps, advanced refrigeration technology, combustion heating systems, and advanced lighting.

FY 1988 funding of $13,450,000 is recommended for this subprogram. These funds will be used to continue research on absorption, Stirling engine, internal combustion engine technology for thermally activated heat pumps; non-azeotropic refrigerant mixtures; advanced magnetically loaded, surface wave and electrodeless high intensity discharge lamp technologies; and the effects of advanced lighting systems on human health and performance.

4.0 ANALYSIS AND TECHNOLOGY TRANSFER

The purpose of this subprogram is to analyze building industry and technology trends to determine BCS research priorities, to transfer the research results of BCS-sponsored projects to the end-use sectors, and to provide program planning support to all the BCS subprograms. Currently, this subprogram provides support for IEA implementing agreements, conducts technical assessments and analyses to support BCS program planning and evaluation, and disseminates information about new technologies.

Funding of $4,000,000 is recommended for this subprogram. These funds will provide continued support for IEA implementing agreements, the building energy data book, the annual analysis of BCS programs, and an evaluation of the program for a twelve year period; will prepare a survey to evaluate acceptance of building energy conserving technologies; will support continuation of a number of technology transfer initiatives including the establishment of an export council from energy conservation products; and will support continuation of the Least-Cost Utility Planning initiative.

5.0 APPLIANCE STANDARDS

The Appliance Standards Subprogram develops test procedures for measuring the energy efficiency of household appliances; analyzes the need for and, if appropriate, develops appliance standards; and supports related educational programs. These subprogram activities are required by the Energy Policy and Conservation Act (EPCA). The household appliance requirements of EPCA are divided between DOE and the Federal Trade Commission (FTC). The FTC is directed to require energy efficiency labels on major household appliances, while DOE is directed to define the test procedures used in developing these labels.

In FY 1987, this subprogram is performing research on the impacts of appliance standards and is processing manufacturers' requests for supervision of State standards. FY 1988 funding of $2,000,000 is recommended to continue these activities and for developing, maintaining, and improving appliance test procedures.

6.0 FEDERAL ENERGY MANAGEMENT PROGRAM

The Federal Energy Management Program (FEMP) was established by the Energy Policy and Conservation Act (EPCA) of 1975 and amended by the National Energy Conservation Policy Act (NECPA) of 1978 to reduce the level of energy consumption by all branches of the Federal government. Specifically, FEMP is charged with achieving the following objectives in existing and new Federally-owned and leased buildings: reducing energy consumption; using energy more efficiently; altering fuel mix to reduce dependence on imported fuel; increasing the use of renewable energy; and transferring applicable energy management experience and technologies among Federal agencies and private sector entities.

FEMP carries out this program through two major activities: Federal Planning, Coordination, Evaluation and Reporting; and Technical Guidance and Assistance to other Federal agencies. FY 1988 funding of $1,000,000 is recommended for this subprogram.

7.0 RESIDENTIAL CONSERVATION SERVICE

This regulatory program consists of the Residential Conservation Service (RCS) and the Commercial and Apartment Conservation Service (CACS). The CACS portion of the program was repealed by the Conservation Service Reform Act (CSRA) of 1986 (Pub. L. 99-412). The same legislation re-authorized, with modifications, the RCS through June 30, 1989. No funding was provided for program development in FY 1987, but staffing was continued to manage RCS and provide assistance to utilities and related groups to encourage voluntary energy efficiency programs using non-Federal funds. FY 1988 funding of $800,000 is recommended for this subprogram for RCS management and assistance for voluntary programs.

8.0 PROGRAM DIRECTION

Funding of $3,650,000 is recommended for 71 FTEs.

10.0 NEW INITIATIVES

A total of $9,250,000 is recommended for 10 new initiatives.

EJECTOR AND TRIPLE EFFECT HEAT PUMPS ($1,500,000)

DOE has been funding research on advanced building equipment, such as heat pumps and appliances, for about eight years. During that time there have been a number of notable successes that have resulted in improved high-efficiency products as a direct result of DOE-sponsored research. Examples include the heat pump water heater and high-efficiency compressors for refrigerators and freezers.

More recently a number of new energy saving and cost-effective concepts have been identified that hold great promise as products. These include the Triple-Effect Advanced Cycle Absorption Heat Pump, the Absorber-Coupled Double-Effect Regenerative (ADR) Heat Pump, an Advanced Ejector Heat Pump, and a Desiccant/Engine-Driven Heat Pump Hybrid. These new concepts promise performance improvements ranging from 50% to more than 100% over the best equipment currently available.

These new concepts come on top of recent substantial advances in research areas currently being funded by DOE, including advanced absorption cycles, internal combustion engine-driven heat pumps, Stirling engine-driven heat pumps, capacity modulating heat pumps, and non-azeotropic refrigerant mixtures.

Pursuing these additional concepts would substantially increase the probability of success, and offer even higher performance improvements over existing equipment.

CHLOROFLOUROCARBON (CFC) SUBSTITUTES ($500,000)

The use of chlorofluorocarbons (CFCs) has become a matter of international environmental concern because these components are suspected of being major contributors to the depletion of ozone in the stratosphere resulting in increased cancer risks from ultraviolet radiation. CFCs also contribute to the so-called greenhouse effect, causing an increase in the average temperature of the earth. CFCs are used for refrigeration and air conditioning, for industrial solvents and foaming agents in the manufacture of plastic foams, and as aerosol propellants.

Because of the chemical structure of various CFCs, there appears to be a wide variation in their potential damage to the ozone layer. R-11 and R-12 remain in the atmosphere for a very long time while other CFCs, such as R-22, have much shorter atmospheric lifetimes so that little of the compound reaches the ozone layer.

While restrictions on the use of CFCs are being discussed, very little work is being done to assess the energy impacts of such a ban. The substitution of R-22 for R-11 or R-12 in some refrigeration applications is a major issue that could determine whether a ban of some CFCs is feasible. Another major issue, with energy implications, is whether other components can be used to produce high-efficiency foam insulations.

Restrictions on the use of certain CFCs without adequate work to determine the technical options could have serious consequences for energy consumption in the U.S. Initial scoping work to determine the areas of greatest need should be started immediately.

EVACUATED PANELS FOR REFRIGERATION ($500,000)

DOE funded work for several years on the use of evacuated panels for insulation in appliances such as refrigerators and freezers. The particular concept being investigated consisted of a fumed silica powder encapsulated in a vacuum bag much like the vacuum-packed coffee currently available in the supermarket. This project was a technical success, demonstrating that it was feasible to achieve insulating values of greater than R-40 per inch using modest vacuums. This performance represents a more than 400% increase over the efficiency of the foams currently being used in appliances.

The development of this concept was discontinued because of budget limitations, even though serious life and durability issues remain to be solved. The Japanese have forged ahead despite these remaining problems, and are currently manufacturing refrigerators using vacuum panels inferior to those developed under the DOE effort.

Other researchers in Europe have been working with similar concepts for other applications. One research group reports having achieved R-160 per inch using aluminum-coated glass fibers in a vacuum. Other concepts have been proposed, including vacuum microspheres or aluminum vacuum panels as in the unbreakable thermos.

Insulations are vital to energy efficiency in all sectors of the economy including buildings, transportation, and industrial processes. The impact on the technical feasibility of reduced use of chlorofluorocarbons for blowing the foam insulations currently used in many applications.

FACTORY-MADE HOUSING ($2,000,000)

Factory-made housing is the wave of the future. It has the potential for reducing the overall cost of housing and at the same time be structurally-sound, extremely energy efficient, aesthetically pleasing and comfortable to the occupant. At present 15% of all new homes in Japan and between 80% and 90% in Sweden and Denmark are factory-made. The Swedish homes have been found to be 50% more efficient than conventional U.S. homes.

This program would be a cooperative R&D effort among DOE, other federal and state agencies, and private sector organizations to create technologically advanced factory-made housing. Research on building components, equipment, services, controls, materials, and design would be incorporated in the advancing manufactured housing industry. The objective of the research is to assist U.S. industry in improving manufacturing processes, marketing strategies, shipping, and market barrier identification, as they relate to energy, in order to make U.S. homes more competitive with foreign homes now being marketed in this country.

The program would establish three regional centers that would, through cooperative arrangements with States, universities and private companies, conduct research and development programs. The Centers would:

1) Identify the state of technology in factory-made housing, this includes identifying innovative technologies for design and building techniques in the U.S. and abroad; study policy and marketing issues related to factory housing including zoning laws, codes, and buyer attitudes; and the identification of technologies that could reduce labor costs.

2) Conduct research on low-cost, high-quality materials, construction techniques, and research and develop design technologies and software to increase design flexibility.

3) Develop methods for integrating existing and future energy technologies into factory-made housing.

4) Research and develop methods for reducing on-site assembly costs, and perform demonstration studies of manufactured buildings to establish reliable technical performance and cost information bases. This information will allow a better understanding of how various factors affect construction and operating costs, and minimize investment risk by industry.

ADVANCED DESIGN TECHNIQUES ($1,000,000)

This initiative is a research program to develop the technical information base for the development of advanced energy efficient building design technologies. The research will complement industrial development in computer-aided design (CADD-CAM), and will take advantage of advanced computer technologies to facilitate the use of larger quantities of data, and the understanding of complex interactions in building systems.

The research would be directed at understanding and developing a structure for the application of logic-based building design. It would identify, develop, and compile the technical data and methodologies to support advanced, computer-supported design systems. This addresses the principal problem in building design, the inability to incorporate large quantities of complex information in the design process. Finally, it would develop methods for integrating advanced computer-supported design tools with commercial CADD-CAM systems. Research in this area includes not only conducting research that allows the development of the interface of an "intelligent" design system with commercially developed computer aided design/drafting systems, but also in conducting research to develop an understanding of how a designer or analyst might interface with such a system.

NEW TECHNOLOGY AND MONITORING CENTER ($1,200,000)

One of the most significant problems facing the U.S. building industry is the lack of research funding. In comparison with the Japanese construction industry, which spends about 3% of its sales on research, the U.S. industry spends 0.01%. Owens-Corning Fibreglas, which had perhaps the largest of all research budgets, has had to greatly reduce its research staff because of a money draining takeover attempt. For a country where housing is 21% of the GNP, U.S. research expenditures on buildings compares with the amount of research on razor blades.

Therefore, this initiative is to develop a center for the monitoring and assessment of advancements in energy conservation technologies to aid industry. It would build on existing analytical resources and serve as a multiple use facility for industry, DOE and other federal agencies, state agencies, utilities, manufacturers, and other organizations. The Center would be a resource for data collection, data management, data acquisition systems, and sensor technology, as well as a facility to test the efficacy of advancements in technology.

The establishment of a center for monitoring and analysis would provide a resource for a large population of users who would otherwise find the cost of accessing this capability prohibitive. Indeed, the core for such a facility has been built through the efforts of DOE, DOD, private utilities and the national laboratories. Expected start-up cost for this facility is $1,200,000. Such a facility would eventually be self supporting with management and operation costs being paid by the users.

TWO PHOTON PHOSPHOR LIGHTING RESEARCH ($250,000)

Lighting by fluorescent lamps consumes about $16 billion worth of electrical energy each year in the U.S. However, by improving the efficiency with which these lamps convert ultraviolet (UV) radiation to light, it is possible to greatly reduce energy consumed by fluorescent lamps. Experts in lighting technology believe it is possible to use improved phosphors -- the coating on the inside of fluorescent lamp tubes that emit light -- to reduce energy used by fluorescent lamps by about 40%.

The present phosphors generate slightly less than one visible photon for each UV photon generated in a fluorescent lamp. It is possible for a UV photon to generate two visible photons by a two stage electron transition from the initial excited state. However, the material must have the proper electronic structure allowing the double decay to occur quickly without energy loss to the crystalline structure. This research will be directed toward a theoretical material study of phosphors coupled with an experiment examining electron transition of excited systems. When suitable phosphors are found, the characteristics relevant for use in a fluorescent lamp will be evaluated.

ADVANCED ENERGY-EFFICIENT APPLIANCES ($1,000,000)

Appliances (excluding central heating and cooling and lighting) account for 42% of residential energy use. Although the efficiency of some appliances has increased substantially during the past 15 years, further large improvements are possible. For example, theoretical studies show that it is economical to reduce the electricity use of the current generation of refrigerators by 75%. This initiative would revive DOE-sponsored R&D on residential appliances, a highly successful research area for DOE during the 1970s. Suggested areas for R&D include:

1) components and designs for more efficient refrigerators and freezers;

2) heat pump and microwave clothes dryers;

3) low-energy dishwashers and clothes washers including improved detergents;

4) condensing and other efficient gas water heaters.

POST-OCCUPANCY LIGHTING EVALUATION ($300,000)

Electric lighting accounts for an estimated one-third of energy use in commercial buildings. While DOE lighting research has concentrated on light fixtures, ballasts and controls, very little research has addressed lighting design. Lighting design guidelines are important determinants of energy use in buildings. Because of inadequate empirical data and analysis existing standards and guidelines are based on professional judgment. Thus, there is little assurance that recommended lighting values provide high user satisfaction and comfort, while requiring the lowest possible energy use.

In 1984, DOE initiated a research project involving occupant evaluations of commercial lighting. The project explored possible causal factors that are associated with successful lighting design, with particular interest in the relationship between the connected lighting power load and subjective measures of lighting quality. This research must be re-started so that an objective measurement base can be developed from which to assess lighting guidelines as well as results that would allow the building industry to make lighting system design decisions that are both energy efficient and effective.

WHOLE BUILDING SYSTEM INTEGRATION LABORATORY ($1,000,000)

The project would develop a laboratory for evaluating the performance of commercial buildings and the interactions among its energy using systems. The laboratory, as presently envisioned, would be a government-owned building. It would be constructed (or modified, if an existing building is selected) so that its components could easily be interchanged for various system interaction experiments. The building would be heavily instrumented to enable collection of information on detailed end-use energy consumption, internal and external ambient conditions (including meteorology), and occupant comfort and (perhaps) productivity.

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

BUILDINGS AND COMMUNITY SYSTEMS
(dollars in thousands)

SUMMARY OF KEY ACTIVITIES

1.0 BUILDING SYSTEMS

Program Activity	FY 1986	FY 1987	DOE Request FY 1988	Alternative FY 1988	Alternative vs. FY 1987
1.1 Building Materials	$1,048	$1,050	$ 0	$ 1,050	-0-
1.2 Building Subsystems					
1.2.1 Wall Research	1,219	600	0	1,000	+$ 400
1.2.2 Roof Research	495	600	400	600	-0-
1.2.3 Fenestration Research	1,523	1,300	0	1,325	+ 25
1.2.4 Indoor Air Quality, Infiltration and Ventilation	1,809	1,900	1,500	1,900	-0-
1.3 Building Systems Interactions					
1.3.1 Commercial	952	1,000	400	1,300	+ 300
1.3.2 Residential	857	0	0	1,300	+ 1,300
1.3.3 Performance Calculation	762	600	0	650	+ 50
1.4 Building Energy Retrofit Research					
1.4.1 Single Family Buildings	651	700	0	700	-0-
1.4.2 Multi-Family Buildings	680	800	500	800	-0-
1.4.3 Commercial Buildings	700	0	0	700	+ 700
1.5 Standards and Guidelines	1,143	400	800	800	+ 400
Sub-Total, Building Systems	$12,124*	$8,950	3,600	$12,125	+$3,175

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* Includes $190,000 for Lighting Quality Research and $95,000 for Control Systems Research. Neither program was funded in FY 1987 nor were requests made for FY 1988.

1.0 BUILDING SYSTEMS

1.1 Building Materials

The Building Materials program studies the basic properties of insulation materials, including loose-fill and foamed-board insulation. This research develops standard methods of testing the thermal properties of insulating materials. DOE has worked closely with the American Society of Tests and Measurements (ASTM) to develop the test methodologies and establish Standard Reference Materials (SRM). In FY 1987, the program is being expanded to conduct basic properties studies on building materials other than insulation, using the Oak Ridge National Laboratory's (ORNL) Flat Screen Test Apparatus and 1-Meter Guarded Hot Plate for static and dynamic test measurements.

In FY 1987, the program will operate under a new research plan. Based on an analysis of the R&D programs of the U.S. and foreign buildings materials industry. This new research plan which had the active support of private industry, concludes that DOE should take a more aggressive role in executing fundamental research that is not being performed by private industry. This would include the study of transient thermal and related thermodynamic conditions, while much of the previous materials data was obtained under static conditions.

There is also a need to determine how applicable the data are for current design practice, what data are missing, and how to get new data that reflects changed thermal performance characteristics. This would require developing fundamental theory and modeling of heat transfer in building materials, providing a better basis for advanced-product development by the private sector. In addition, it will be important to forecast long-term trends in resource availability and product/design innovations that will determine the requirements of future building materials.

In FY 1988, the program will continue to focus materials performance characterization that includes, development of materials performance information, analytical models and standard reference materials. Characterization projects are then scheduled to decrease significantly, while advanced materials technology development becomes the dominant part of the program. Advanced technology will cover high-risk, long-term materials science and concept development (such as advanced concretes, low-conductivity structural ties, and exterior coating) for eventual transfer to private industry.

1.2 Building Subsystems Research

1.2.1 Walls Research

In 1982, with extensive input from industry, a National Program Plan for the thermal performance of building envelope systems was prepared. The Plan, and its several revisions, has been used by DOE as the basis for its walls and roofs research program.

The wall systems research has focused on four areas - performance of walls, thermal mass, thermal anomalies, and foundations. Walls research evaluates the measurement and prediction of wall thermal performance and the correlation between field and laboratory performance measurements and performance predicted by analytic techniques. The program provides designers with specific knowledge about how composite walls will perform under differing climatic conditions. Current program efforts include support for the Calibrated Hot Box at the National Bureau of Standards (NBS), which is used to evaluate the dynamic performance of walls. This information is then used in several analytical tools developed for the buildings industry.

In FY 1988, the wall systems program will continue to research the dynamic, thermal, moisture and infiltration properties of homogeneous and non-homogeneous wall systems. This work is needed to better understand how currently built systems perform under different climate conditions. The results also are used by the buildings industry to develop new, more efficient wall systems. The NBS Calibrated Hot Box will continue to be the measuring tool.

The thermal mass research is directed at high-mass materials that store thermal energy under dynamic conditions. Such material can cause substantial energy savings in buildings beyond those attributable to the U-factor of the envelope. The thermal mass program is coming to a close and the results of the research are being provided to the ASHRAE 90.2 Committee on residential construction.

Thermal mass research will be terminated in FY 1987 with the exception of the preparation of an assessment of the research needs and the energy savings potential of interior thermal mass and of the cooling effects of thermal mass.

Thermal anomalies research studies regions with unusually high heat transfer accounting for a loss of as much as 30%-40% of building heat and significant moisture damage caused by condensation. These anomalies include such things as apartment building balconies and metal building studs. The research is designed to identify, analyze, and catalog thermal anomalies, to develop reliable algorithms for use in analytical models. In FY 1988, a handbook for commercial buildings design will be prepared. The thermal anomalies work will continue with several technical papers being prepared. Topics include the thermal effects of convective loops and of common thermal bridges.

The final area of wall systems research is in the foundation systems. Foundations research tries to minimize the amount of heat lost through foundations, which in many buildings can be substantial. Preliminary studies suggest that at least some insulation is cost-effective in almost all parts of the country. A panel of American and Canadian experts has developed a research agenda that stresses research algorithm validation, assembly of a data base, and development of design tools. A foundation systems handbook analyzing how to best integrate the energy and non-energy (moisture, radon, structure, etc.) elements of foundations was ranked as the highest priority. In FY 1987, each of these areas will be addressed.

In FY 1988, a volume of the Foundation Systems Handbook for architects and engineers will be prepared followed in six months by a similar volume for builders. Work will continue on the introduction of up-to-date algorithms for whole building analytical models.

1.2.2 Roof Research

Each year about $10 billion is spent on low-slope roofing in the United States. About two-thirds of all new roofs develop problems within three years that degrade thermal performance and lead to extensive litigation. DOE has developed a roof research program that has the potential to substantially reduce the incidence of roof failures, extend the lives of roofs by several years, and save the nation approximately 0.5 quads of energy per year.

The mainstay of the research will be in the extensive use of the Roof Research Center (RRC) at ORNL. The capabilities to measure and model the thermal, moisture and mechanical performance of a variety of roof systems will be combined for the first time at the RCC. The center, developed with broad industry support, has been designated a National User Facility, which commits the Center to extensive industry involvement in the research. In FY 1987, the RRC test chamber will be installed, calibration tests will begin, and a research plan will be adopted.

In FY 1988, the calibration of the RRC's main test chamber will be completed. In addition, efforts will continue to fully equip and instrument the test center through cost-sharing projects with the roofing industry. The operation of the RRC is scheduled to begin in FY 1988 as the research agenda is put into place and outside research projects are actively sought.

In addition to the RRC, a small facility for in-situ thermal performance experimentation on roof systems has been constructed at ORNL. This facility, called the Roof Thermal Research Apparatus, is used for monitoring and observing the performance of 4 X 8 foot, low-slope roof sections, which are implanted with sensors for monitoring temperature, heat flow, and moisture conditions.

In FY 1987, an analysis of one-dimensional transient thermal performance of insulated roof systems will be completed. In addition, research will be conducted on the effects of surface mass on thermal performance and guidelines on the effects of surface reflectance and surface mass will be developed.

In FY 1988, ORNL will continue performance studies and corroborating results of the roof test apparatus. The emphasis of the research will be on problems raised by the roofing industry. Basic research will also be conducted on roof energy efficiency and durability, again in cooperation with industry.

To obtain more reliable data on the effect of moisture on roofs, DOE has initiated a project to develop a non-intrusive moisture probe. This will be similar to probes used extensively in production line operations in which product quality is dependent upon moisture content. DOE intends to introduce the probe to roof manufacturing where applying the technology is complicated by the wide range of moisture concentrations and materials that exist in roofs. In FY 1987, the calibration of the probe and a moisture study at MIT will be completed, allowing the development of a prototype for industry to be initiated.

In FY 1988, the moisture probe prototype will have been completed and the quantitative measurement technology will be available to industry for commercial development.

Detailed mathematical modeling of how changing climatic conditions affect the thermal performance of roofs is also an important part of DOE's roof research. Current modeling activities include a general purpose thermal performance model called START, application of DOE-2 (the Department's computer program stimulating building energy use) to roof solar absorption, and a moisture migration and phase-change model.

The START model will be completed and verified through a limited three-dimensional thermal analysis of insulated roofing systems.

ORNL and DOE are also preparing a new International Energy Agency Annex (project) on low-slope roofs. Acting as Operating Agent for the Annex, ORNL will work with other participating countries.

1.2.3 Fenestration Research

The Fenestration Research Program has four responsibilities. The first is to develop a technology base to help the window industry develop advanced glazing materials. Its major effort has been the development of low-emissivity (low-E) coatings for residential windows. Low-E coatings increase the thermal resistance of windows by lessening radiative heat transfer. This successful technology is being used by several major window manufacturers. Low-E coated windows now constitutes 25% of the residential market and the percentage is climbing. In FY 1987, work on a titanium nitride-based durable low-E sputtered coating will be completed and ready to transfer to industry. Advanced glazing research will concentrate on the development of materials that can reduce heating and cooling loads, and enhance daylight use in buildings. This study of high-R window technology will emphasize multiple low-E coatings on evacuated glazings with gas-filled systems.

New fenestration materials and components with improved capabilities to regulate heat loss and gain are needed. Work will therefore continue on the development of hard low-E coatings to replace the soft coatings now in use by industry. This will increase the availability of low-E windows because of less expensive manufacturing costs and also increase the market for commercial building application. In addition, work will continue on the development of high-R windows. These windows will have a significant impact on energy savings, because of lower heat loss and gain, and on occupant comfort, because designers won't be constrained to limit window size and number by energy cost.

The second and third responsibilities of the Fenestration Research Program are the development of analytical tools, experimental techniques, and field measurement facilities to accurately predict thermal, solar-optical, and daylighting performance of fenestration components and systems and the development of a sound technical basis for understanding and predicting net fenestration performance in residential and commercial buildings. These areas have included the development of daylighting design tools that have totally altered the design industry's approach to daylighting design. In FY 1987, Lawrence Berkeley Laboratory (LBL) will work with the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) to develop a new methodology for determining solar heat gain from complex fenestration systems. This work and other field testing using the Mobile Window Thermal Test Facility (MoWiTT) will provide a validated data base on advanced window performance and validate simulation models such as SUPERLITE (a daylighting model) and WINDOW 2 (a glazing selection model).

In addition to the development of advanced technology, it is critically important to analyze fenestration performance to better utilize existing and new technologies. This requires developing new techniques to measure and evaluate component heat-loss, heat-gain, and daylighting properties under varying operating conditions. New simulation models will allow optimal fenestration selection in all building types and climates. Accurate field measurements, using MoWiTT in outdoor tests and in monitored buildings, are required to confirm simulation results. Results of simulations and field tests will be used to update and revise design fundamentals and the DOE and ASHRAE new building standards. This work will also be the technical basis for a new generation of "smart" design tools as well as suggesting the need for, and potential of, new technology.

The final area is the development of appropriate design tools to make this information available to the building industry. In FY 1987, studies of low-E window performance in residences will be completed and attention will shift to development of a residential design tool incorporating all DOE knowledge of window energy effects in residences. The Florida Solar Energy Center (FSEC) will adapt a builders handbook on fenestration to provide a model design guide for Southeastern home builders. Technical roof research studies of commercial buildings will focus on performance of roof shading systems. A skylight design handbook will be completed and collaborative work with the Lighting Research Institute will continue to develop a new guide based upon performance indices established by LBL and FSEC.

In addition, work will continue on providing the design industry with up-to-date guidance on the technology of applying low-E coatings.

1.2.4 Indoor Air Quality, Infiltration and Ventilation

Concern about conserving energy in the mid-to-late 1970s led to efforts to reduce air infiltration and ventilation rates, which in turn led to increased concern about indoor air quality. In response, DOE initiated a research program that evaluates the relationships among infiltration, adequate ventilation and acceptable indoor air quality. This research program, coordinated with other research programs within and outside of DOE, has contributed significantly to our understanding of indoor radon and its mitigation, emissions from unvented supplemental heating devices, indoor air quality control techniques, and infiltration and ventilation in buildings.

For FY 1987, this research will focus on four areas: 1) identifying sources of indoor radon and developing energy efficient radon mitigation techniques; 2) studying indoor air quality, infiltration, and ventilation (IAQIV) performance in buildings; 3) developing, testing, and evaluating control techniques to mitigate indoor pollutant levels; and 4) developing advanced instrumentation and techniques for measuring and modeling infiltration, air leakage, ventilation and indoor air quality.

The results from this research will provide information to both the public and private sectors necessary to advance energy conservation technologies that maintain healthful indoor environments.

In FY 1988, DOE will continue working with the Bonneville Power Administration to identify and quantify sources of indoor radon, to assess the variability of ambient radon levels, and to identify radon entry mechanisms into, and behavior within buildings, and to demonstrate energy efficient radon mitigation techniques that emphasize new construction techniques. Work will continue on the development and evaluation of energy efficient and cost-effective source control and ventilation strategies to maintain indoor air quality. This will include testing and evaluating displacement ventilation techniques for non-residential applications.

DOE will continue to work with the private sector to maintain and expand indoor air quality field studies to provide information to builders and designers as well as to interested researchers. This Concentrations of Indoor Pollutants (CIP) data base is co-funded by the Electric Power Research Institute and the Gas Research Institute. Interagency efforts will continue on the development an indoor air quality model, initial laboratory and field testing will be initiated in FY 1988. Research on indoor air quality, infiltration and ventilation performance of large buildings is being conducted by performing pollutant and ventilation measurements in conjunction with an epidemiologic survey. Two buildings will be analyzed in FY 1988. Technical reports will be completed on measurements in a Washington, D.C. office building, and on performance of a "sick" building. This work is done in conjunction with the development of an active technique for measuring multi-zonal air leakage in large buildings. The first such effort is the measurement of multi-zonal air infiltration in large multifamily buildings using a multi-tracer gas technique.

Work will continue on the development of a simplified multi-zone infiltration and ventilation model that will study the effects of occupant behavior on infiltration and ventilation. This will expand the work on multi-zone infiltration models and multiple tracer gas measurement techniques. Finally, DOE has been very active in the development of voluntary industry consensus standards for ventilation and indoor air quality through the American Society for Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).

1.3 Building Systems Interactions Research

1.3.1 Commercial Building Systems Interactions

Studying Commercial Building Systems Interactions is necessary because energy-efficient commercial buildings cannot be designed just by assembling good components any more than good automobiles can be designed simply by assembling good but arbitrarily selected parts. The building design community needs to understand how whole buildings uses energy before it can produce an energy-efficient design.

The program is a "systems" approach, integrating the results of component-specific research projects into cost-effective strategies that can minimize building energy consumption. To date, research has focused on five major areas:

1) Development of cost-effective energy conserving design strategies for multifamily high-rise residential buildings;

2) Survey and collection of hourly end-use energy consumption data in commercial buildings;

3) Development of whole building energy targets;

4) Advanced planning and prototype development for next generation design tools development; and,

5) Planning of long-range, high-risk advanced systems research.

Specifically in FY 1987 and 1988, research will focus on three projects: intelligent building design and operation technology, design process research, and integration of building component tests to whole building performance (dynamic interaction). Intelligent building technology is a new project that will draw upon current systems integration and building subsystem research and upon new long-term research. The products of the research will be simplified analysis tools, interface between design and computer aided design and drafting (CADD) tools, and development of databases to support advanced design tools. Such research will be integrated into a knowledge-based advanced design system.

Design process research will investigate how decisions affecting energy conservation are made during various stages of building design. Projects are focused in three areas: understanding the design process, integrating conservation strategies into the design process (software development), and delivering research results to the design community.

Dynamic interaction research will involve rigorous measurements of building envelope components. Research results will be integrated with a recently-developed simulation framework, and then be made available for ASHRAE and ASTM evaluation.

1.3.2 Residential Systems Interactions Research

Even with major advances in energy conservation, new homes in the U.S. are still up to 50% less efficient than homes in Scandinavia. This lack of efficiency creates higher than needed residential energy demand; makes home owning more expensive; and opens the U.S. market to foreign competitors who are building more efficient homes at lower prices.

Most energy conservation research in the U.S. has been directed at building components rather than the building as a system. This is partly due to the earlier lack of information about the impacts of existing energy conservation technologies and partly because of the fragmented nature of the building industry. But we have learned from other countries that significantly greater energy savings can be achieved when buildings are considered as a whole unit. Advanced Housing Research studies the effect that the building envelope, HVAC equipment, appliances, lighting, people and weather together have on the amount of energy that buildings use. For example, in Sweden, where new homes use on average 50% less energy for heating than do new homes in the U.S., to building design consider the weather, the lifestyle of the population, the building materials at hand and the availability of fuels.

Over the past ten years, DOE has helped promote energy conservation for housing. This is a worthwhile investment given that residential energy use comprises 23% of annual U.S. energy consumption. The DOE can build on its past efforts, which have concentrated on improving the efficiency of separate components, such as better insulated ceilings, walls and floors, and higher quality windows. As the DOE's Energy Research Advisory Board points out, "Because buildings represent a complex interaction of thermodynamic processes, an integrated systems approach is necessary to expose the more significant opportunities for energy savings. Past DOE programs have emphasized the development of individual energy technologies and materials with less regard to the integration process in whole buildings. To achieve maximum savings, the building industry needs to know the most effective combinations of passive and conservation techniques for various building types and climatic regions. Integrated system studies, of course, complement and guide R&D on individual technologies; they are not substitutes for them."

FY 1988 research will look at ways to reduce energy used for cooling, which has not received as much attention as that paid to reducing heating loads. This is partially because cooling research isn't possible without considering building components simultaneously. There is a large market for the products of such research. The U.S. housing stock has changed from 1966, when 25% of new single-family homes had air-conditioning, to 1983 when almost 70% did. Although much of the research would examine high humidity/high heat areas, findings could be applied to more temperate climates.

A second area of concern is the competition provided by foreign builders of factory built housing. In a relatively short time, the Japanese have "industrialized" their residential building process, thereby reducing costs and improving the energy efficiency of new homes. The U.S. industry requires an intensive research program like the one funded by the Japanese government in order to update industry design and construction processes. Such research will make the industry better able to provide more affordable housing, especially to low and moderate income families.

1.3.3 Performance Calculations

Research on building performance calculations was begun to support the Building Energy Performance Standards (BEPS) program. In addition, such research was needed to develop a standard method for calculating building energy use that would enable researchers and building designers to optimize energy- and cost-efficient designs and strategies. This research met its goals and has led to a whole building energy use simulation program (DOE-2) used by researchers and building designers, operators and managers.

Plans for FY 1987 and 1988 include updating and maintaining the current version of DOE-2, and continuing research on advanced building energy use simulation tools. This research is based on state-of-the-art knowledge of building energy design and equipment and will make use of advanced algorithms to simulate building energy use.

The advanced simulation research effort involves many researchers defining both an overall structure for an advanced building energy simulation program and developing individual program modules to address specific applications (for example, indoor air quality). An overall structure for advanced simulation will allow researchers to test and easily incorporate new algorithms for building energy simulation as they are developed. In addition, the new program structure will allow building researchers, designers, and operators and managers to combine algorithms to suit their individual requirements. This research effort will improve the accuracy and usefulness of building energy simulation programs.

1.4 Building Energy Retrofit Research

There is a wide range of devices and materials that can be applied to new or existing buildings to improve energy efficiency. However, little is known about the interaction of these technologies or their effect on actual energy consumption when used in occupied buildings.

The benefits of many building retrofit programs have not been of the magnitude initially projected. This is attributable to many factors including poor workmanship, inaccurate benefits-estimation techniques, and changes in the behavior of building users after retrofits were done. Accordingly, building owners remain hesitant to undertake what are theoretically extremely cost-effective actions. Consequently, there is an urgent need for a systematic, multi-year research program to measure the actual impact of retrofit measures when applied to a broad range of existing, occupied residential and commercial buildings in various climates throughout the United States.

In FY 1985, detailed plans were prepared for single-family, multifamily, and commercial building retrofit research. These plans identify the retrofit research needs and describe the priority projects to be investigated over the next 6 years. This research program focuses on those building types where information is weakest and the need of building owners and occupants is greatest, including low-income housing, multifamily buildings, and small and medium size commercial buildings. Special attention is given to those existing or new technologies with the broadest potential application and the largest potential savings for the lowest cost. In addition, emphasis will be placed on measuring the effects of operations and maintenance on energy consumption in existing buildings. The focus of this work is on developing diagnostic tools for identifying more efficient operations and maintenance strategies, improving training for operators, and designing energy-efficient service packages for smaller buildings not benefiting from commercially available maintenance services.

Research on retrofitting residential heating and cooling systems, public and federally assisted housing, institutional buildings, and smaller retail and office buildings will continue to receive a high priority.

1.4.1 Single Family Buildings

In FY 1988, improvements will be made to single family retrofit monitoring protocols based on results of field tests. Work will continue on the monitoring of residential structures in hot and humid climates to assess performance of envelope measures and mechanical equipment modifications. Development will begin on new, innovative residential retrofit technologies applicable to both cold and hot climatic regions. Results of monitoring and technology development will be transferred to state and local agencies for application through builders, contractors, and various user groups. DOE will continue to work with the American Society for Testing and Materials (ASTM) and the American

Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) to encourage the adoption of DOE-developed monitoring protocols as accepted industry standards.

1.4.2 Multifamily Buildings

In FY 1988, data resulting from previous retrofit protocol monitoring will be analyzed and revisions to multifamily monitoring protocols will be made. DOE will support work on multifamily retrofit monitoring of building envelope measures and mechanical equipment modifications. Work will continue on standard diagnostic procedures for determining air infiltration in multifamily buildings. Study will continue on the effects on occupants of multifamily retrofit measures. Again, DOE will work with ASTM and ASHRAE to encourage adoption of multifamily retrofit monitoring protocols as accepted industry standards.

1.4.3 Commercial Buildings

In FY 1988, DOE will complete the initial development of standard protocols for collecting and analyzing of performance data from retrofit measures in small commercial buildings. Several retrofitted commercial buildings will be monitored to verify the accuracy of these standard protocols. Development will begin on innovative approaches for application to commercial building retrofit, and their performance relative to predicted levels will be tested through installation and monitoring. Research will be completed on the study of management practices and decision making in the commercial buildings sector to determine the types of retrofit strategies most likely to be adopted by building owners and operators.

1.5 Standards and Guidelines

Title III of Pub. L. 94-385 requires DOE to issue performance standards applicable to all new buildings. These standards are to be voluntary guidelines for the nonfederal sector and mandatory, when adopted by the affected agency, for the federal sector. Federal agencies have the option of adopting the mandatory standards or they may develop their own standards that meet or exceed the DOE standards. There is a need to review and update these standards as new technological developments in the buildings industry improve energy performance.

In FY 1986, DOE completed proposed interim energy conservation standards for new commercial and multi-family high rise residential buildings and residential buildings built for use by the Federal government. On August 20, 1986, DOE published a Notice of Proposed Rulemaking (NOPR) in the Federal Register requesting public comment on the Federal residential standards. Public hearings were held in October 1986 in Chicago, San Francisco and Washington, D.C. At the conclusion of the comment period comments were analyzed, and the Federal residential standards are be revised and published as an interim rule. Federal agencies that construct residences for their own use will be obliged to follow the standards.

An NOPR for the commercial and multi-family high rise residential building standards is being published in FY 1987. As with the Federal residential standards, there will be a lengthy comment period. Public hearings will be held in San Francisco, New Orleans and Washington, D.C. DOE expects to complete the analysis of public comments on the standards in FY 1987 and commence preparation of the interim rule.

In FY 1988, DOE will issue the interim standards for new commercial and multi-family high rise buildings. Following issuance of the two aforementioned interim standards, DOE will initiate a Congressionally-mandated demonstration program intended to test the energy saving attributable to the standards and their affect on the building industry. Also in FY 1988, DOE will complete the voluntary standards for new residential buildings. This project, as were the commercial and multi-family high rise residential building standards, is a joint project with ASHRAE. Since ASHRAE energy conservation standards have been chosen for use by over 40 states, DOE has decided to work closely with ASHRAE in developing future standards. Related commercial and residential standards will be published by ASHRAE on about the same schedule as the DOE standards.

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

BUILDINGS AND COMMUNITY SYSTEMS
(dollars in thousands)

SUMMARY OF ACTIVITIES

2.0 COMMUNITY SYSTEMS

Program Activity	FY 1986	FY 1987	DOE Request FY 1988	Alternative FY 1988	Alternative vs. FY 1987
2.1 District Heating and Cooling					
2.1.1 Advanced Fluids	$367	$400	0	$400	-0-
2.1.2 Components Research	340	283	0	400	+ $ 117
2.1.3 Advanced Systems	267	217	0	400	+ 183
2.1.4 Feasibility Assessments	720	0	0	500	+ 500
2.2 Community Energy Systems Integration					
2.2.1 Urban Consortium	1,903	2,000	0	2,000	-0-
2.2.2 Site Design	216	0	0	200	+ 200
Sub-Total, Community Systems	$3,813	$2,900	0	$3,900	+ $1,000

2.0 COMMUNITY SYSTEMS

Conservation for community energy systems have potentially significant benefits, high capital costs and varying degrees of technological uncertainty. Private sector sources of research funding for community systems are very limited. Unfortunately, BCS conducts basic research on system technologies and assists communities in identifying and evaluating the potential of community energy systems.

2.1 District Heating and Cooling

District Heating and Cooling (DHC) is a utility system that produces thermal energy in centralized facilities and delivers it through a common distribution network for many uses including building heating or cooling, domestic water heating, and industrial process heating. The heat-carrying medium in a district heating network can be water or steam that is heated: 1) directly by boilers burning fossil fuels, municipal waste, or biomass; 2) through heat exchange with low-temperature heat resources such as ground water or industrial waste energy; or 3) through cogeneration, in which electricity and thermal energy are produced simultaneously. Similarly, district cooling media can be chilled by a variety of methods including heat exchange with low-temperature resources (water, air), mechanical refrigeration cycles, and absorption refrigeration cycles.

DHC systems compete with individual building heating and cooling systems in the U.S. urban marketplace. And, although research and development has contributed to considerable improvements in the efficiency of these individual building systems, similar efforts have not been undertaken in the area of DHC.

DHC provides a number of benefits that make it attractive in some locations when compared with individual-building cooling systems. Significant energy savings are attainable when it is combined with electric-power production through cogeneration processes. DHC also allows solid fuels such as coal, biomass, or solid waste to be used as energy sources, because they can be burned in an environmentally acceptable manner in large central stations. Another advantage of DHC is its ability to utilize low-temperature energy sources such as groundwater, geothermal heat, and waste heat captured from power plants and industrial processes.

To obtain these benefits, however, DHC must be economically competitive with individual heating and cooling systems. Research and development is needed to reduce development and operations costs and to provide for flexibility in energy-source utilization. In 1985 and 1986, the Community Systems program conducted exploratory studies that led to a decision to focus research in three technology areas in FY 1987 to FY 1992: nonconventional sources and systems, piping and distribution systems, and advanced fluids.

Few available technologies can now exploit local energy sources in DHC applications in a cost-effective and environmentally acceptable manner. Research is needed for heat pumps that can effectively boost low grade energy up to temperatures suitable for DHC; for DHC systems that can efficiently operate at low temperatures and service low-density areas; for heat exchangers that are capable of operating in chemically hostile environments; and, for technologies that can be used to retrofit older district heat systems.

construction techniques. This is particularly true in the area of piping and distribution equipment, which can total up to 70% of total DHC system cost. Research is also needed to develop low-cost yet accurate thermal meters for revenue measurement and new piping materials and piping-systems designs that can be installed inexpensively and that are reliably for long periods. Also needed are low-cost methods for converting existing heating systems to operate with DHC systems and methods to accurately monitor the condition of buried piping systems.

All DHC systems have been based on the use of water (or steam) as the energy-transmission medium due to its negligible cost. Preliminary investigations have indicated that several properties of water can be significantly altered by additives that improve its energy-carrying capacity and reduce energy losses in the DHC distribution process without increasing environmental risks. Research is needed to expand on these findings to focus on 1) improving fluid flow by the addition of additives that reduce frictional losses in distribution systems (slippery water); 2) development of solid/liquid slurries (liquid ice) and chemical-energy transport/storage for use in increasing the cooling-energy capacity of district cooling systems; 3) development of phase-change material additives for use in increasing heat-energy capacity of district heating systems; and 4) development of additives that will inhibit piping corrosion and improve leak-detection capability in distribution systems.

2.1.1 Advanced Fluids

In FY 1988, laboratory and field testing will continue on selected drag reduction additives through cost-shared programs with universities and DHC system operators. Other work will include identifying the physical and thermodynamic properties of materials having the potential to greatly increase the heat transport capacity of district heating systems. Development will continue on technologies applicable to the production and transport of ice slurries for district cooling applications. Laboratory development will continue on selected waxes and clathrate compositions capable of increasing the cooling energy capacity of district cooling systems.

2.1.2 Components Research

Field tests of an acoustic leak detection system will be carried out in an operating municipal DHC system. Development will continue of an open cycle heat pump capable of utilizing low temperature heat sources for district heating, and advanced-cycle (water-glycol) absorption chiller capable of producing ice slurries for district cooling applications. Research will continue on developing low cost non-metallic materials for use in 190-300°F district heating distribution systems. Field tests will be performed on submerged heat exchanger designs capable of extracting low grade thermal energy from various water resources. Development and testing will continue on an accurate, low cost thermal energy meter design. The advanced component designs will be tested at the Argonne National Laboratory DHC Test Center under cost-shared agreements with industry participants.

2.1.3 Advanced Systems

District cooling alternative technologies will be assessed using the City of Austin, TX system as a model. The cost of this project will be shared with the American Public Power Association. A similar cost-shared installation and testing project of selected DHC retrofit technologies will be performed in Scranton, PA. An economic assessment and systems analysis of modular cogeneration integrated into DHC development will be continued.

2.1.4 Feasibility Assessments

Twelve to fifteen cities will be selected for assessing the feasibility of developing DHC systems, with emphasis on district cooling development. In addition, the results of other recently completed feasibility assessments will be distributed to the communities, local governments, and DHC developers. DOE will initiate testing of innovative DHC technologies by cities currently undertaking independent DHC development.

2.2 Community Energy Systems Integration

A major determinant of energy use in an urban area is the pattern and density of its physical development; the interrelationship of land use, public services, and transportation activities; and sources and type of energy provided to a community. Developers and municipal officials are reluctant to introduce new development concepts that are more energy efficient. This is because of the increase in construction time, lack of direct improvement in return on investment, uncertain market acceptance, and overlapping roles of community officials, utilities, and private developers. Research is needed to establish new development concepts at both the neighborhood and community scale; provide the basic scientific data that developers need to test and prove the effectiveness of these new concepts for their specific applications; and develop public and private sector investment strategies to implement new development patterns. Also needed are information exchange, education, and training programs that develop professional skills in community energy planning.

2.2.1 Urban Consortium

DOE will award research grants to approximately 20 cities and counties for development and application of innovative technologies and management tools to local government operations. Applications include water supply and waste treatment, resource recovery, street lighting, and municipal building operation. The development of cost-effective public and private financing techniques applicable to local government and community energy conservation projects will also be explored. Information gained from the projects will be shared with other cities and counties.

2.2.2 Site Design

Work will continue evaluating the effect of tree placement and density on wind velocity and other micro-climate features. Selection will be made of several different building and landscaping configuration in several different climate regions to determine the effects on energy use and occupant comfort.

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

BUILDINGS AND COMMUNITY SYSTEMS
(dollars in thousands)

SUMMARY OF KEY ACTIVITIES

3.0 TECHNOLOGY AND CONSUMER PRODUCTS

Program Activity	FY 1986	FY 1987	DOE Request FY 1988	Alternative FY 1988	Alternative vs. FY 1987
3.1 Thermally Activated Heat Pumps					
3.1.1 Absorption Technology	$2,315	$2,500	$2,300	$4,050	+ $1,550
3.1.2 Stirling Engine Technology	1,160	1,500	0	2,600	+ 1,100
3.1.3 I. C. Engine Technology	1,000	1,000	0	1,500	+ 500
3.2 Advanced Refrigeration Systems	2,188	1,800	400	2,100	+ 300
3.3 Combustion Systems Research	958	650	0	1,150	+ 500
3.4 Lighting Research					
3.4.1 Lighting Equipment Research	1,914	1,240	900	1,250	+ 10
3.4.2 Lighting Impacts Research	550	360	400	400	+ 40
3.4.3 Building Lighting Application Research	200	200	400	400	+ 200
Sub-Total, Technology and Consumer Products	$10,285	$9,250	$4,400	$13,450	+ $4,200

3.0 TECHNOLOGY AND CONSUMER PRODUCTS

The structure of the consumer products industry is more definable and cohesive than, for example, the buildings industry. The industry historically has focused its R&D efforts on developing improved manufacturing techniques and processes rather than on new, energy-efficient products. BCS-sponsored research in the area of energy conservation technology and consumer products focuses on the identification and evaluation of new technologies that can be incorporated by industry in consumer products. BCS's programs are basic research oriented towards long-term product improvements.

3.1 Thermally Activated Heat Pumps

Thermally activated heat pumps have the potential to achieve Coefficients of Performance (COPs) of at least 1.8 in heating and 1.0 in cooling. When compared to the most efficient gas-fired pulse-combustion furnace with an efficiency of 95%, the thermally activated heat pump offers potential energy savings of up to 5.0 quads of energy in the U.S. residential and commercial sector by the year 2010.

Three novel advanced cycle absorption heat pump concepts are being funded. Supporting research in pump development, novel absorption fluids, materials, corrosion, and system modeling is needed to evaluate thermal and physical effects. Research is required to advance these designs of heat pumps driven by the free-piston Stirling engine and the internal combustion engine. Supporting research in refrigerant sealing techniques, such as the bellows seal, is needed for hermetic sealing of the engine/compressor assembly, and endurance testing of the seal assembly is required. It is necessary to test the response of heat pump systems to a wide range of operating conditions. Substantial basic research is needed to establish the technological basis for high-COP, low-cost, thermally activated heat pumps. Novel concepts in ejector heat pumps and desiccant cooling systems need to be investigated.

3.1.1 Absorption Technology

In FY 1988, DOE will initiate development of triple effect cycles capable of higher efficiency in air conditioning in commercial buildings. Basic fluids research will be initiated to identify and synthesize fluids capable of high temperature operations and/or additives to improve thermophysical properties. DOE will also develop and evaluate laboratory "breadboard" systems targeted to applying advanced space heating concepts to commercial water heating and residential air conditioning systems.

3.1.2 Stirling Engine Technology

Hardware development of a second generation engine will be initiated. The development of a new hydraulic transmission/compressor design will focus on manufacturing cost, durability and efficiency. DOE will also assemble "breadboard" hardware for an additional alternative transmission concept.

3.1.3 I.C. Engine Technology

Support will be continued of cost-shared field test efforts on the I.C. engine. Researchers will explore solutions to the remaining key questions about the potential for manufacturing a commercial-size unit. Design of a residential size unit will be completed and development of prototype hardware will be initiated. The long-term evaluation of alternative hermetic seal systems will continue.

3.2 Advanced Refrigeration Systems

As used for heat pumps and refrigeration systems in industry and in residential and commercial buildings, the Rankine vapor compression cycle is one of the major sources of electric-power consumption in the U.S. Energy-efficiency improvements in these systems have been made through private and federal research programs. Basic research on the underlying thermodynamics of this cycle is needed to continue improvements in existing equipment. Research in this area will also be applicable to thermally activated heat pumps.

In FY 1988, research will focus on non-azeotropic refrigerant mixtures to include separation techniques and composition controls. Research will be completed on capacity modulation. Work will be initiated to minimize or eliminate use of chlorofluorocarbon refrigerants. DOE also continue assessing new concepts for alternative cycles including the Stirling refrigeration cycle.

3.3 Combustion Systems Research

A significant opportunity exists to improve the efficiency of combustion-heating equipment. Average equipment efficiencies in the field are 60 to 65% for residential systems and 80% for large commercial systems using gas and oil fuels. With solid fuels (wood and coal), conversion efficiencies range between 35 and 70%. The efficiency of gas and oil equipment can be increased to 95% under condensing operation, but full implementation of this approach is being thwarted by material corrosion problems and high costs. Research is needed in low-cost materials, heat-exchanger dynamics, corrosion phenomena, and compatible combustion systems for this efficiency-improvement opportunity to be fully realized.

In FY 1988, DOE will continue research and development on high efficiency oil heating systems, including venting, combustion, controls, and diagnostics. Research will also continue on thermal distribution systems in residential buildings, focusing on the physics of heat loss and zonal heating approaches. A study of the dynamics of forced-air residential distribution systems in the air conditioning mode will be completed.

3.4 Lighting Research

Although the theoretical efficacy limit for a luminous white-light source is around 250 lm/W, the standard fluorescent lamp operates at an efficacy of only 70 lm/W. There is a need, therefore, to learn how the light is lost by studying discharge plasma physics, and to devise techniques to recapture those losses. Development of a light source with a luminous efficacy of 200 lm/W should result in potential annual savings of 400 billion kWh of electric energy.

Several methods of reducing losses in low-pressure discharge lamps (fluorescent) have been identified, but further research and development is required to advance these new technologies. These approaches include magnetically loaded lamps (25% improvement); high-frequency, electrodeless low-pressure lamps (30% improvement); electrodeless, high-pressure lamps with novel gas fills (50%); and isotopically enriched mercury gas for low-pressure lamps (5-15% improvement). These improvements based on existing technology would be cumulative. Initial research has also begun developing an efficient and economic mercury-isotope separation process so that supplies of enriched mercury may be available when the enriched mercury lamp is fully developed. Further work is needed to develop the candidate separation process if energy savings are to be realized. Fundamental, diagnostic research into the molecular and atomic behavior of lamp-discharge phenomena is also necessary to fully understand the energy-loss mechanisms and suggest new approaches to eliminate losses in the lamp discharge process.

In order for new light-source developments to be fully integrated into buildings, there is a need to better design illuminated building space to achieve maximum energy-to-light conservation efficiency. The design and operation of commercial building equipment systems can be improved by investigating the interaction of lighting systems with HVAC and envelope systems. This will significantly reduce both first costs and annual energy consumption by as much as 30%.

To correlate space-luminance relationships to occupant response, a mathematical relationship needs to be developed that relates the spatial distribution, color distribution, and brightness of light sources to the response of persons using the space. A quantitative physical definition of lighting quality will permit lighting designers to compare the performances of different types of lighting environments and their effect on occupant behavior.

3.4.1 Lighting Equipment Research

In FY 1988, DOE will investigate techniques for applying magnetic fields to magnetically loaded fluorescent lamps. Significant performance variables in the surface wave length lamp phenomena will be identified and evaluation will continue on lamp driving power supply concepts. Research will be initiated on advanced laser diagnostics for investigating optically thick and thin discharge plasma phenomena. Research will be performed on the significant variables of the prototype electrodeless high intensity discharge (HID) lamp. Finally, research will be initiated applying the surface wave concept to driving high intensity discharge lamps over a range of 50 to 500 watts of lamp power.

3.4.2 Lighting Impacts Research

In FY 1988, research will characterize pupillometry effects by light source stimuli and continue to quantify additional human responses to light sources. Researchers will evaluate the light source effects on video display terminal (VDT) operators and evaluate visual fatigue. Work will be initiated on an experimental evaluation of lighting systems related to visual and task performance and productivity.

3.4.3 Building Lighting Applications Research

In FY 1988, work will continue on advanced lighting designs using high efficiency systems components. Experimental data from the Commercial Buildings Systems Interactions Program on lighting, HVAC and envelope interactions will be analyzed as a prelude to developing a lighting quality design metric.

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

BUILDINGS AND COMMUNITY SYSTEMS
(dollars in thousands)

SUMMARY OF KEY ACTIVITIES

4.0 ANALYSIS AND TECHNOLOGY TRANSFER

Program Activity	FY 1986	FY 1987	DOE Request FY 1988	Alternative FY 1988	Alternative vs. FY 1987
4.1 Technical Assessment and Analysis					
4.1.1 IEA Support	$100	$100	$100	$100	-0-
4.1.2 Building Energy Accounting	584	500	500	500	-0-
4.1.3 Export Council on Energy Conservation Products		0	0	200	+$ 200
4.1.4 Twelve-Year Evaluation of BCS Programs		0	0	200	+ 200
4.2 Least Cost Utility Planning	951	1,000	0	2,000	+ 1,000
4.3 Technology Transfer	959	400	400	1,000	+ 600
Sub-Total, Analysis and Technology Transfer	$2,594	$2,000	$1,000	$4,000	+$2,000

4.0 ANALYSIS AND TECHNOLOGY TRANSFER

4.1 Technology Assessment and Analysis

Determination of the appropriate mix of technologies, and the level of effort for each, requires a detailed assessment of each technology. This provides the baseline for determining the potential costs and benefits to society and the appropriate federal role.

International Energy Studies U.S. technology leadership, foreign imports controlling over significant shares of the U.S. market, and the international balance of payments issue require continued analysis of the conservation technologies, practices, and programs in foreign countries.

Planning and Assessments Effective planning, management, and evaluation of the Buildings and Community Systems program requires a comprehensive assessment of all current and potential projects. The assessment must consider the likely future demand for the products resulting from the research and the probable technical success and cost effectiveness of the research.

Effective planning and evaluation also requires quantification of the energy-conservation designs, techniques, technologies, and practices that have been installed in buildings, how much of which kinds the industry intends to install or use, and what kinds of new designs, techniques, technologies, and practices are needed. Accurate information can be obtained only through a statistically reliable sample of the several key parts of the buildings industry. A 2-year study is required because currently only incomplete bits and pieces of information are available.

Investment Decision Analysis A recent study by Battelle Pacific Northwest Laboratories for the Bonneville Power Administration found that in many areas, those producing, selling, and installing building conservation technologies have very different perceptions from those buying or using the technologies or practices. The buyers had more concern about energy conservation (48% versus 17%), were more concerned about energy use in the home (48% versus 23%), believed the U.S. energy situation was serious (30% versus 3%), and thought that the energy situation would get worse in the next 5 years (32% versus 1%). They also differed in the investments they had made in conservation ($1811 versus $598) and were more likely to use current income and savings to finance past conservation investments (75% versus 25%). To effectively transfer R&D results to the private sector, it is important to increase understanding of those perceptions about when, what, and how much users are willing to invest in buildings energy conservation.

In FY 1988, DOE will continue support for IEA implementing agreements; continue studies of building conservation technologies used in developed countries and assess its effect on international trade and U.S. technology leadership; maintain the Building Energy Accounting Systems (BEAS); publish a data book; and conduct the annual analysis of current and proposed BCS programs and conduct strategy analysis for future years programs. DOE will also design and plan a survey to evaluate acceptance and success of buildings energy conserving technologies and practices.

4.2 Least Cost Utility Planning

The effects of energy-conservation technologies and techniques on the demand side of the utility customer's meter is of growing concern for the utility industry. Better analytical tools, data, and information are needed by utilities for estimating future generating-capacity needs, and rate-setting. DOE can help the utility industry develop new analytical tools and also provide data to the industry.

In FY 1988, DOE will assess the cost and performance potential of advanced lighting, thermally activated heat pumps, and other new technologies capable of improving utility load shape and reducing electrical peak demand. There will be an evaluation of consumer acceptance of direct load control, time-of-use rate structures, thermal storage, and similar utility conservation strategies. DOE will continue cooperative research activities in technology assessment, market penetration, integrated utility analysis, and transferring new technologies to industry. Key participants with DOE in the research include the Electric Power Research Institute, Edison Electric Institute, and the National Association of Regulatory Utility Commissioners. A publication called "EnergyGrams" will be issued periodically describing the results of the research.

4.3 Technology Transfer

Accelerating private-sector application of energy-conserving building technologies developed in BCS R&D Programs is complicated by the fragmented nature of the building industry. The building industry is predominantly composed of many small and medium size firms involved in a variety of activities including research and development, planning, design, construction, manufacture, distributions, operation, and regulation. There is also fragmentation across the residential, commercial, and industrial sectors, with each sector functioning largely as a separate industry with little information technology exchange among them.

Because of this fragmentation, BCS works with trade and professional organizations to provide information to these diverse audiences. These organizations can be used to assess R&D needs, disseminate research results, and evaluate the technology-transfer process.

In certain circumstances, it is most useful for BCS to work with one firm or a small number of firms to transfer a technology. Such partnerships provide firms with sufficient incentives to develop and vigorously market a technology. Firms are generally reluctant to contribute much to a commercialization process if competing firms have equal access to the new technological property. To successfully engage in such cooperative efforts, it is necessary to identify suitable and willing industrial partners and to determine effective cooperative arrangements.

The diversity of the buildings industry makes it difficult provide R&D results to potential users. Needs assessments are necessary to determine users' research and information needs as well as the forms in which this information is desired. An inventory of technology is also needed as part of this assessment to identify all technologies ready to be used.

It is necessary to produce materials that synthesize and explain research results in design tools, software, databases, bibliographies, exhibits, reports, and abstracts and fact sheets. While BCS has been successful in the transfer of research information to the technical community through articles in technical journals, it has not made as extensive use of references used by manufacturers, distributors, practitioners and consumers such as exhibits at trade shows, handbooks, and fact sheets. Such information channels will be considered in future efforts to reach a broader audience.

Outreach activities are needed to provide educational opportunities and disseminate information tailored to the needs of various audiences in the buildings community. While BCS R&D findings are reported extensively to other researchers at technical meetings, there is considerably less outreach to practitioners and other nontechnical audiences. Increased participation at trade and professional association meetings, personal communications with key decision-makers, and distribution of printed materials through the BCS computerized mailing lists are ways of improving the outreach to non-technical audiences.

Finally, evaluation and feedback are necessary to assess the effectiveness of the technology transfer program. This should include the development of a list of detailed examples of the successful transfer of technology from BCS to private industry or State and local government.

In FY 1988, the technology transfer system will be improved to monitor research progress and ensure that research results are transferred quickly, efficiently, and effectively to the private sector. DOE will continue to work with other organizations and associations to sponsor workshops, symposia, conferences, and committees to quickly and effectively share BCS research results. DOE will also continue the publications of state-of-the-art reports on selected aspects of efficient use of energy in buildings, building equipment, and community systems. Finally, DOE should also develop a program plan to establish an export council that would assist small and medium sized companies in marketing and exporting innovative conservation equipment technology, such as heat pumps, lighting, windows, and housing, in foreign countries.

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

BUILDINGS AND COMMUNITY SYSTEMS
(dollars in thousands)

SUMMARY OF KEY ACTIVITIES

5.0 APPLIANCE STANDARDS

Program Activity	FY 1986	FY 1987	DOE Request FY 1988	Alternative FY 1988	Alternative vs. FY 1987
5.1 Test Procedures and Consumer Education	$833	$800	$500	$800	-0-
5.2 Appliance Standards Development	1,073	1,200	1,300	1,200	-0-
Sub-Total, Appliance Standards	$1,906	$2,000	$1,800	$2,000	-0-

5.0 APPLIANCE STANDARDS

Title III, Part B, of the Energy Policy and Conservation Act (EPCA) (Pub. L. 94-163), as amended, requires DOE to develop standard methods of testing 13 types of appliances and to develop energy-efficiency standards for the same 13 types of appliances. The test procedures are the basis of any energy-use, energy-efficiency, or cost-of-operation claim, and are the basis of the value that appears on the Energy Guide label that the FTC requires on seven types of appliances. Research is needed to update these test procedures as new products are introduced into the marketplace and to reduce testing burden. Energy-efficiency standards research is needed to meet the legislative and judicial requirements that DOE establish standards for appliances. The research performed will support the Department's rulemakings in this area.

5.1 Test Procedures and Consumer Education

In FY 1988, DOE will continue research to develop, maintain, simplify and improve test procedures for appliances (furnaces and central air conditioners) in support of the FTC labeling program. It will also process manufacturer requests for the modification of appliance test procedures.

5.2 Appliance Standards Development

In FY 1988, DOE will continue to perform research on the effects of appliance standards (including publishing a notice of proposed rulemaking for 13 types of appliances and analysis of comments). DOE will also continue to process manufacturer requests for supersession of State standards.

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

BUILDINGS AND COMMUNITY SYSTEMS
(dollars in thousands)

SUMMARY OF KEY ACTIVITIES

6.0 FEDERAL ENERGY MANAGEMENT PROGRAM

Program Activity	FY 1986	FY 1987	DOE Request FY 1988	Alternative FY 1988	Alternative vs. FY 1987
6.1 Federal Planning, Coordination, Reporting and Evaluation	$264	$365	$300	$300	-$ 65
6.2 Program Technical Guidance and Assistance	950	585	700	700	+ 115
Sub-Total, Federal Energy Management Program	$1,214	$950	$1,000	$1,000	+$ 50

6.0 FEDERAL ENERGY MANAGEMENT PROGRAM

The Federal Energy Management Program is a Congressionally-mandated program to reduce the level of energy consumption by all branches of the federal government. The FEMP office assists both civilian and military organizations in planning, managing, and achieving reductions in energy consumption. Among the activities it carries out are:

- Developing and implementing a "Methodology and Procedures for Life Cycle Costing Analyses." The handbook on LCC methodology is the primary criterion for allocating funding for energy conservation retrofits to existing federal buildings, as well as for selecting energy systems in the design of new federal buildings. The energy price and discount factor tables that are used to supplement the LCC manual are updated annually. LCC seminars are conducted periodically so that federal energy managers may get "hands-on" experience in using the LCC procedures.

- Sponsoring "Energy in Design" workshops, conducted by the American Institute of Architects, that provide an opportunity for energy managers to incorporate energy considerations into the building design process.

- Developing the Federal 10-Year Buildings Plan, in cooperation with other federal agencies, for improving energy efficiency in all federal buildings to the maximum extent practicable within the constraint of LCC effectiveness. The plan provides a systematic planning framework for implementation of agency plans, while recognizing the diversity of agency missions and building stock. Standards of efficiency that agencies must use are to be no less stringent in performance characteristics than standards developed by the ASHRAE and the Illuminating Engineering Society (IES).

- Publishing a quarterly newsletter, FEMP UPDATE, which keeps the federal community abreast of activities of interest to their programs and activities.

- Administering the Federal Energy Efficiency Awards, which are presented annually by the Federal Interagency Energy Policy Committee (the "656" Committee) to federal employees and organizations that achieve noteworthy success in their energy conservation programs.

- With the passage of "shared savings" legislation in April 1986, FEMP is undertaking a government-wide initiative to introduce multi-year energy management service contracting to federal procurement officials, legal officers responsible for overseeing contracts, and top level managers and administrators of the various agencies. It is also providing "hands-on" technical assistance in developing RFPs, evaluating responses, and negotiating shared-savings contracts.

- FEMP will work with the Buildings Systems Program to implement the Federal commercial and residential buildings. FEMP is initiating training sessions for federal construction managers to ensure that the standards are met.

6.1 Federal Planning, Coordination, Reporting and Evaluation

In FY 1988, FEMP will continue to prepare annual reports to the President and to Congress on the status of the Federal agencies' progress in meeting the goals of FEMP. It will monitor agencies' energy consumption data and provide trend data to management. Work will continue to evaluate the effectiveness of shared-savings contracts and of pilot shared-savings projects to determine effectiveness.

FEMP will continue to coordinate agencies' activities through meetings of energy coordinators and periodic meetings of the "656" Committee. It will also administer the Federal Energy Efficiency Awards program and coordinate Federal agencies' participation in Energy Awareness Week.

6.2 Program Technical Guidance and Assistance

In FY 1988, FEMP will continue to update the life cycle cost (LCC) factors and provide changes to the manual. It will continue assistance to federal agencies implementing shared-savings projects and also continue workshops for LCC analyses, "Energy in Design", employee awareness and mandatory building standards. FEMP will also continue exchanging information with IEA participating countries.

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

BUILDINGS AND COMMUNITY SYSTEMS
(dollars in thousands)

SUMMARY OF KEY ACTIVITIES

7.0 RESIDENTIAL AND COMMERCIAL CONSERVATION SERVICE

Program Activity	FY 1986	FY 1987	DOE Request FY 1988	Alternative FY 1988	Alternative vs. FY 1987
Sub-Total, Residential and Commercial Conservation Service	$381	$0	$0	$800	+ $800

7.0 RESIDENTIAL AND COMMERCIAL CONSERVATION SERVICE

In the absence of an appropriation for RCS in FY 1987, DOE continued the staff management of the program focusing on revisions to the program regulations and identification of other changes necessary to conform the program to the Conservation Service Reform Act of 1986 (CSRA). Staff assistance was also continued to utilities and related groups to encourage voluntary energy efficiency programs using non-federal funds.

In FY 1988, with renewed funding, the management of the RCS program would continue. This would include a review of plan amendments and utility requests for waivers from plan requirements and supply/installation prohibitions. The office will monitor state and utility compliance with CSRA and activate the RCS Federal Standby program if necessary. The program staff will provide technical assistance to states and utilities through regional workshops and other means on the most cost-effective conservation procedures and devices and the most successful RCS plan. RCS is required to report annually to Congress. A project will be conducted to demonstrate innovative technologies for utility application that increase energy efficiency in commercial buildings.

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

BUILDINGS AND COMMUNITY SYSTEMS
(dollars in thousands)

SUMMARY OF KEY ACTIVITIES

8.0 PROGRAM DIRECTION

The requested funding will provide salaries, benefits and travel for a staff of 71 FTEs to manage the Building and Community Systems Program.

Program Activity	FY 1986	FY 1987	DOE Request FY 1988	Alternative FY 1988	Alternative vs. FY 1987
Sub-Total, BCS Program Direction	$3,639	$3,650	$2,650	$3,650	-0-

9.0 CAPITAL EQUIPMENT

Program Activity	FY 1986	FY 1987	DOE Request FY 1988	Alternative FY 1988	Alternative vs. FY 1987
Sub-Total, Capital Equipment	$1,906	$750	$ 278	$1,800	+ $1,050

9.0 CAPITAL EQUIPMENT

The capital equipment budget is required to carry out and complement the research programs being conducted in building energy conservation. This budget will be used to procure instrumentation; construct specialized apparatus for conducting experiments; procure computer hardware and workstations; modify and construct laboratory facilities; procure prototype products developed from research programs; and, procure products to facilitate the involvement of industry in DOE research and development efforts.

The following are example projects requiring capital funding: Roof Research Center Test Chamber, the Lighting program, the Heat Pump program, the Building System Integration programs, the Fenestration and Daylighting Program, the Advanced Design Techniques initiative, the New Technology and Monitoring Center, and the Whole Building System Integration Laboratory.

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

BUILDINGS AND COMMUNITY SYSTEMS
(dollars in thousands)

SUMMARY OF KEY ACTIVITIES

10.0 NEW INITIATIVES

Program Activity	FY 1986	FY 1987	DOE Request FY 1988	Alternative FY 1988	Alternative vs. FY 1987
Sub-Total, New Initiatives	-----	0	0	$9,250	+ $9,250
TOTAL, BUILDINGS AND COMMUNITY SYSTEMS	$37,862	$30,450	$14,578	$51,975	+$21,525

MULTI-SECTOR PROGRAMS

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

MULTI-SECTOR ENERGY CONSERVATION
(dollars in thousands)

LEAD TABLE

	FY 1986 Actual	FY 1987 Appropriation	FY 1988 Alternative	FY 1988 Request	Alternative vs. FY 1987
1.0 Energy Conversion and Utilization Technologies	$18,327	$20,358	$22,100	$15,800	+$ 1,742
Capital Equipment for ECUT	952	1,000	800	127	- 200
Program Direction for ECUT	510	546	600	489	+ 54
2.0 Inventions and Innovation	4,705	5,000	6,000	3,290	+ 1,000
3.0 National Appropriate Technology and Assistance Service	1,428	1,400	1,500	700	+ 100
4.0 New Initiatives			2,000	-0-	+ 2,000
Total, Multi-Sector R&D	$25,922	$28,304	$33,000	$20,406	+$ 4,696
Staffing, Total FTE	6	9	9	8	+ 1

1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

MULTI-SECTOR ENERGY CONSERVATION

OVERVIEW

The Multi-Sector budget account includes three program areas - Energy Conversion and Utilization Technologies, Inventions and Innovation and the National Appropriate Technology Assistance Service. Each is discussed separately below.

FY 1988 ALTERNATIVE FUNDING RECOMMENDATION FOR THE ECUT PROGRAM

To continue research on advanced energy conversion and utilization technologies, a level of $23,500,000 is recommended for ECUT R&D program direction and capital equipment. The specific breakdowns are outlined in the specific subprogram areas that follow.

1.0 ENERGY CONVERSION AND UTILIZATION TECHNOLOGIES (ECUT)

The primary mission of ECUT is to conduct generic cross-cutting R&D to assist DOE end-use conservation programs (Industrial Programs, Transportation Programs, and the Building and Community Systems) as well as providing U.S. industries with the advanced technology base for increasing energy efficiency.

The strategy of the ECUT program is to support exploratory development of selected technologies, processes and inventions to a point where proof-of-concept is shown and a proven technology can be transferred to end users. Emphasis is on technologies with strong technical and energy savings potential, and those that are too high risk or long term for other conservation programs or private firms to pursue. R&D activities are focused in the following areas: combustion, thermal sciences, materials, catalysis/biocatalysis and tribology. The ECUT program also monitors international activities. ECUT R&D helps future U.S. competitiveness by advancing the transition of basic scientific research into industrial applications.

Program Accomplishments

Despite its focus on long term R&D, the ECUT program has demonstrated key successes that will revolutionize the technical base of the transportation, industrial and sectors.

- The materials program developed the first ductile ordered intermetallic (Ni_3Al) that can operate at higher temperatures than current metals. It is already being licensed to Cummins Engineering Co., Indiana, for review and exploration for advanced energy efficient engine development.

- Combustion research has resulted in new (e.g., laser based) diagnostics to measure turbulence, fuel air distribution, temperature, pressure within combustion chambers of operating internal combustion engines.
- ECUT thermal sciences program completed exploratory development of spirally fluted (enhanced surface) heat exchanger tube that shows 100% improvement in heat transfer capability over conventional smooth tube configuration.
- Tribology research has demonstrated that vapor deposition is effective for providing lubrication at temperatures above 350°C, the range of high-temperature heat engines.
- Biocatalysis research resulted in a bench scale fluidized bed bioreactor that increases ethanol productivity using micro-organism biocatalysis. Its future benefit includes less energy intensive chemical reactions, by using micro-organism processing, conducted at lower temperature than current processes.
- ECUT funded demonstration of processes to eliminate nitrogen oxides from combustion by-products by using a common non-toxic cyanuric acid that converts exhaust nitrogen oxides into molecular nitrogen and other gases. This R&D may result in the establishment of a new company in 1987 to commercialize the process. The application could result in more efficient catalytic converters in automobiles and cleaner combustion in stationary generation, and may offer potential for export if successful.

COMBUSTION

Combustion is the fundamental process for converting fuels into usable energy. Improved combustion techniques, including continuous, intermittent and pulsed, have application in transportation, industry, buildings and utilities. The combustion subprogram focuses on understanding fluid mechanics and combustion processes in engines and continuous combustion systems. This includes developing of computer models, analysis of the chemical and physical properties of the combustion process, and exploring advanced concepts. Funding of $5,450,000 should be provided to continue this effort.

THERMAL SCIENCES

The Thermal Sciences subprogram conducts research to develop advanced energy conversion and heat and mass transfer devices that will improve energy efficiency. The program R&D is directed to develop and apply new analytical techniques to understand fluid mechanics, thermodynamics and heat transfer processes. These R&D efforts could result in providing the private sector with the needed capabilities to design and develop heat transfer devices and systems with lower cost and higher reliability. Program funding of $2,160,000 should be provided for this subprogram.

MATERIALS

The Materials subprogram conducts research on high temperature, light weight, and corrosion resistant materials to improve energy system performance and efficiency. An integral part of ECUT materials research is the implementation of the materials-by-design concept to apply understanding of the behavior of materials at the atomic level to predict how desired properties can be engineered into such high temperature materials as intermetallics. The materials-by-design concept, by using advanced computers and diagnostics, has the potential to dramatically improve the success rate for developing new materials over that of time-consuming and expensive conventional experimental test procedures. The subprogram is also conducting R&D on monolithic ceramics, exploring the properties of complex ceramic systems and ceramic joining techniques. The Materials Subprogram also investigates the possibility of recycling plastics to reduce the petroleum-based feedstock needed to produce plastics as well as to improve disposal methods. Funding for this subprogram should be at a level of $6,955,000.

CATALYSIS/BIOCATALYSIS

The Catalysis/Biocatalysis Subprogram conducts R&D to develop the analysis and technology base to enable private industry to use genetically engineered micro-organisms or enzymes (biocatalysts) for the economically competitive production of chemicals. The technology base for bioprocess engineering is being improved through investigation of several innovative high productivity bench scale reactor concepts that could result in economic and less energy intensive biochemical production. Funding of $3,495,000 is proposed for Catalysis and Biocatalysis research.

TRIBOLOGY

The Tribology Subprogram concentrates R&D on the study of friction, lubrication and wear and has the potential for significantly reducing energy use in engines and equipment by lessening losses in moving parts and high wear areas. For example, analysis of automotive energy use show that about 20% of the useful energy output of the automobile is lost to internal engine friction and another 12% goes to overcoming transmission and axle friction losses. Even a 25% improvement in these areas would lead to an annual energy savings of 1.0 quad (approximately 0.5 MBPD). This R&D also contributes to the potential for producing adiabatic engines of the future. Funding of $3,710,000 is recommended for the Tribology Subprogram.

In other ECUT accounts, funding levels of $330,000 should be provided for the International Monitoring and Conservation analysis activities. Funding for capital equipment of $800,000 is recommended to assure program use of state-of-the-art equipment and $600,000 for program direction to manage the overall effort.

2.0 INVENTIONS AND INNOVATIONS

The Inventions and Innovations Program develops ideas of individuals and small businesses to improve energy efficiency. There are two programs: the Energy-Related Inventions Program and the Innovative Concepts Program. The Energy-Related Inventions Program, jointly operated with the National Bureau of Standards, evaluates and supports promising energy-related inventions and concepts. From its inception in 1974 through 1986, approximately 23,000 inventions have been evaluated and grants totaling $17 million have been awarded. Of these, 73 inventions have entered the marketplace, generating sales of approximately $200 million. The Innovative Concepts Program solicits and supports the development of novel energy concepts. In FY 1987 the program will conduct a competitive solicitation on innovative energy conversion devices. Illustrative of the program's success is the development of high pressure cylinders made of reinforced metal with fiberglass for transportation of natural gas. ALCOA purchased the technology for such applications.

Funding of $6,000,000 is recommended for FY 1988.

3.0 NATIONAL APPROPRIATE TECHNOLOGY ASSISTANCE SERVICE (NATAS)

The goal of the National Appropriate Technology Assistance Service (NATAS) is to help the American public investigate and use appropriate technologies and to help solve problems in commercializing energy savings products and services. NATAS provides individual engineering, scientific, and technical responses to questions and information requests posed by homeowners, small businesses, farmers, state and local governments, and nonprofit institutions. A recommended funding level for FY 1988 is $1,500,000.

4.0 NEW INITIATIVES

Funding of $2,000,000 is recommended for the new initiatives decided below.

INTERNATIONAL ENERGY CONSERVATION RESEARCH MONITORING ($500,000)

This initiative will establish a national information resource on international technology development that would be accessible to U.S. industry and Federal agencies for developing or planning U.S. conservation R&D and applications. Many countries have ambitious programs in energy efficiency R&D. If made aware of their research results, U.S. researchers could benefit greatly; U.S. researchers could avoid "inventing the wheel," and take advantage of much high quality information that is available for the asking. Many foreign countries have long monitored U.W. efforts in this area. The U.S. should commit itself to the same kind of effort.

ADVANCED ELECTROCHEMISTRY R&D FOR CORROSION RESISTANT METALS AND ADVANCED MONOLITHIC SOLID OXIDE FUEL CELL FOR TRANSPORTATION APPLICATION ($1,500,000)

Recent advances in R&D indicate the potential for using advanced monolithic fuel cells for utility and transportation application. The monolithic fuel cell employs a unique cell design with thin ceramic components to form an extremely compact, solid state device. The feasibility of this design has been demonstrated on a laboratory scale. However, several years of further research and development are needed to make the monolithic fuel cell practical. The monolithic solid oxide fuel cell had the long range potential to conserve fuels and to meet a variety of national energy needs. These include powering airplanes and automobiles, and producing electricity more efficiently than today's electric power plants. Coordinating its research with DOE Fossil programs - ECUT will investigate application of the monolithic fuel cell to transportation application

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

MULTI-SECTOR ENERGY CONSERVATION
(dollars in thousands)

SUMMARY OF KEY ACTIVITIES

1.0 ENERGY CONVERSION AND UTILIZATION TECHNOLOGIES

Program Activity	FY 1986	FY 1987	DOE Request FY 1988	Alternative FY 1988	Alternative vs. FY 1987
1.1 Combustion					
1.1.1 Engine Combustion Technology	$ 4,075	$ 4,000	$ 4,000	$ 4,360	+$ 360
1.1.2 Continuous Combustion	900	800	1,000	1,090	290
1.2 Thermal Sciences					
1.2.1 Advanced Heat Transfer	500	800	0	655	- 145
1.2.2 Advanced Conversion Technology	629	1,000	100	1,505	+ 505
1.3 Materials					
1.3.1 High Temperature Materials	3,324	3,600	3,200	3,925	+ 325
1.3.2 Materials by Design	1,396	1,500	1,500	1,630	+ 130
1.3.3 Lightweight Materials	800	1,100	800	1,200	+ 100
1.3.4 Corrosion - Resistant Materials	131	200	0	200	-0-
1.4 Catalysis/Biocatalysis					
1.4.1 Bioprocess Engineering	2,578	2,400	2,250	2,455	+ 55
1.4.2 Catalysis-by Design	74	608	250	710	+ 102
1.4.3 Applied Microbiology	0	250	0	0	- 250
1.4.4 Bioseparations	0	300	0	330	+ 30
1.5 Tribology					
1.5.1 Lubricants	1,100	1,300	1,200	1,420	+ 120
1.5.2 Mechanisms of Friction and Wear	500	550	250	545	- 5
1.5.3 Friction and Wear Testing	500	100	0	110	+ 10
1.5.4 Tribological Surface Modifications and Coatings	1,445	1,050	550	1,090	+ 40
1.5.5 Tribological Design Tools	235	600	500	545	- 55
1.6 International Research Monitoring	140	100	100	165	+ 65
1.7 Conservation Program Analysis and Planning	0	100	100	165	+ 65
1.8 Innovative Concepts	0	0	0	0	-0-
Sub-Total, Energy Conversion and Utilization Technologies	$18,327	$20,358	$15,800	$22,100	+ $1,742

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

MULTI-SECTOR ENERGY CONSERVATION
(dollars in thousands)

SUMMARY OF KEY ACTIVITIES

	Program Activity	FY 1986	FY 1987	DOE Request FY 1988	Alternative FY 1988	Alternative vs. FY 1987
	CAPITAL EQUIPMENT FOR ECUT	$ 952	$ 1,000	$ 127	$ 800	-$ 200
	PROGRAM DIRECTION FOR ECUT	510	546	489	600	+ 54
2.0	INVENTIONS AND INNOVATIONS	4,705	5,000	3,290	6,000	+ 1,000
3.0	NATIONAL APPROPRIATE TECHNOLOGY AND ASSISTANCE SERVICE	1,428	1,400	700	1,500	+ 100
4.0	NEW INITIATIVES			-0-	2,000	+ 2,000
	TOTAL, Multi-Sector Energy Conservation ..	$25,922	$28,304	$20,406	$33,000	+$ 4,696

STATE AND LOCAL ASSISTANCE

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

DEPARTMENT OF ENERGY

SUMMARY OF ESTIMATES BY APPROPRIATION BY MAJOR ACTIVITY
(dollars in thousands)

STATE AND LOCAL ASSISTANCE PROGRAMS

	FY 1980 Actual	FY 1986 Actual	FY 1987 Appropriation	FY 1988 Alternative	FY 1988 Request	Alternative vs. FY 1987
Institutional Conservation Program (Schools & Hospitals)	$143,800	$ 44,888	$ 25,170*	$ 40,050	$ 0	+ $14,880
State Energy Conservation Program (EPCA Grants)	37,800	17,903	9,400*	15,750	0	+ 6,350
Energy Extension Service	25,000	7,300	3,970*	6,750	0	+ 2,780
Weatherization Assistance Program ...	199,000	182,084	161,460*	162,450	0	+ 990
Territories Assistance	N/A	476	0	500	0	+ 500
Program Direction	N/A	9,745	13,500	13,500	6,000	-0-
Other	26,200	N/A	N/A	N/A	N/A	N/A
Total, State and Local Assistance Programs	$431,800	$262,396	$213,500	$239,000	6,000	+ $25,500

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* Under the terms of the Omnibus Reconciliation Act of 1986, and a determination by the DOE Office of Hearings and Appeals, $134 million of FY 1987 funding will be derived from the oil overcharge escrow account. An additional $66 million was appropriated for FY 1987, and is available pending an Administration recision request.

FY 1988 ALTERNATIVE BUDGET RECOMMENDATIONS

U.S. DEPARTMENT OF ENERGY

STATE AND LOCAL ASSISTANCE PROGRAMS

OVERVIEW

State Energy Offices deliver energy-saving services under three federally-mandated programs, the State Energy Conservation Program (SECP), the Energy Extension Service (EES), and the Institutional Conservation Program (ICP). These programs, along with the Low-Income Weatherization Program, make up the State and Local Assistance Programs.

These programs increase energy efficiency in the industrial, commercial, agricultural, institutional, transportation, and residential sectors through a wide variety of programs which provide technical training, demonstrations, energy cost-saving analyses, and incentives for energy conservation. They are a vital part of the nation's energy plan which serves to reduce dependency on foreign energy sources, meet energy needs cost-effectively, and reduce energy operating costs in businesses and homes.

Continued Federal funding will sustain these State and Local Assistance Programs which serve to:

- o Help protect the national security from the threat posed by the recent surge in levels of imported oil and the prediction of dramatic oil price increases which together can lead to the re-occurrence of an oil crisis;
- o Help reduce the high national cost of energy, which made up 21% of the 1986 national trade deficit;
- o Move the U.S. manufacturing sector into a more competitive stance internationally by reducing costs of products through energy operating cost reductions;
- o Provide the technical information and services to homeowners, small businesses, schools and hospitals that enable them to cumulatively save millions of dollars each year and reduce energy demand by 10-20% in public buildings, commercial enterprises and residences.

The funding request level of $239,000,000 for the State and Local Assistance Programs for FY 1988 ensures that every state will be able to maintain adequate delivery of services for each program.

Oil overcharge restitution funds, which will supplement Federal funding over the next three to five years, can bolster energy programs in the short term, but they by no means exhaust the range of energy-saving services needed by all sectors of the economy.

The basic State and Local Assistance Programs, funded through Federal dollars, allow the states to strengthen the energy efficiency gains of the last decade, and they allow the nation to obtain the goal of reducing dependency on foreign energy sources.

INSTITUTIONAL CONSERVATION PROGRAM, or the Schools and Hospitals Grant Program was established to encourage energy conservation initiatives in the institutional building sector. Such public and private non-profit institutions use significant amounts of energy, the cost of which represents a large proportion of their operating budgets. As a result, energy conservation measures can result in significant energy and economic savings. Through FY 1986, the program awarded over 20,000 grants for energy conservation projects in over 57,000 school and hospital buildings. The program has also had notable secondary effects in stimulating energy-saving activities and developing expertise in energy conservation in participating institutions. This program requires a 50% match of funds from the institutions which carry out technical analyses of energy costs and installations of energy conservation measures.

STATE ENERGY CONSERVATION PROGRAM (EPCA Grants) provides states with the means to plan and implement energy conservation programs that reduce energy consumption in each state. Fifty states, D.C. and 6 territories have developed energy efficiency plans and are implementing specific energy conservation and renewable energy programs in the commercial/industrial, agricultural, transportation and residential sectors. SECP supports activities that address the specific energy issues in each state. The states have also developed and are maintaining an energy emergency planning and response network, a database of information on energy use and energy conservation efforts statewide, and state-wide "networks" of organizations involved in energy activities. SECP also allows for demonstration projects to promote energy conservation and energy efficiency.

ENERGY EXTENSION SERVICE provides tailored information and technical assistance to smaller scale energy users (i.e., businesses, local governments and homeowners) to help them decide what are their most effective and productive energy conservation and renewable energy options. The demonstration of energy technologies and techniques, hands-on workshops, on-site technical assistance and "how-to" workbooks are the principal methods utilized by EES to meet the needs of the energy consumer. EES functions as an integrating and coordinating mechanism for existing resources and delivery mechanisms, providing new/updated information and sound technical advice. EES also provides a referral service to assist energy consumers.

WEATHERIZATION ASSISTANCE PROGRAM increases the energy efficiency of residences occupied by low-income citizens across the country, particularly in homes of the elderly and handicapped. It is estimated that approximately 14.4 million households at or below 125% of the poverty level are eligible to receive assistance under this program. Low-income households are least able to respond effectively to the market signal of higher prices by making energy conservation investments. Through FY 1986, approximately 1.7 million low-income homes were weatherized under this program.

EXAMPLES OF SUCCESSFUL STATE AND LOCAL ASSISTANCE PROGRAMS

Listed below are examples of successful programs funded through the Federal State and Local Assistance Programs (SECP, EES and ICP). These are only a small sampling of the results which have occurred in energy efficiency and conservation programs at the state level. They indicate the potential for increased energy savings possible with future funding of these programs through Federal appropriations.

STATE ENERGY CONSERVATION PROGRAMS

In Alaska, a major emphasis of the State Energy Conservation Program has been the development of an energy mortgage valuation program in the state. Energy mortgage valuation qualifies more buyers for better built and move energy efficient homes through recognizing energy efficiency in negotiating the debt to income ratio on mortgage loans. A home receives an energy rating by a trained real estate appraiser and a break is given according to the home's energy rating.

The state's effort was a cooperative effort by the private sector, local governments, utilities and the State. The Department of Community and Regional Affairs provided the technical support and coordination necessary to begin the development of the program. $20,000 in State Energy Conservation Program funds were used to develop the rating sheets and the initial training conducted for appraisers and mortgage lenders.

The management of the program has been taken over by a committee of bankers, realtors, builders and appraisers called Energy Rated Homes of Alaska. State involvement in the first year will be in the marketing of the program. This will be supported with $90,000 in Energy Extension Service and State Energy Conservation Program funds. After this project has been completed the program will be run entirely by the private sector.

The Alaska Housing Finance Corporation, which finances a great majority of homes in the state has incorporated energy mortgage valuation into its program and will give up a 2% credit on the debt to income ratio according to the home's rating.

The State of Alaska considers this program an excellent example of a private and public sector partnership. The relatively small amount of State Energy Conservation Program's funds that were placed into it have been leveraged into an ongoing successful program that has been picked up the private sector. This program has an additional benefit in that it presents a new avenue to qualify homebuyers in a depressed housing market.

In Massachusetts, the Executive Office of Energy Resources (EOER) developed the Energy Advisor Service (EAS) in 1983 to assist the states' manufacturers in identifying opportunities and strategies for energy cost containment. EAS, as envisioned, would contract with private sector engineers to provide on-site analysis of energy consumption and to develop site specific recommendations for investments and improvements. In addition, a statewide network of local marketing agents would be developed to enlist clients and to oversee the delivery of services.

By the end of 1985, more than 100 Massachusetts industrial firms, ranging in size from 20 employees on the low end to General Motors on the high end, had requested to participate in the EAS. The initial analysis of EAS has been impressive illustrating that:

- Savings identified for most clients have equaled a minimum of ten (10) percent of the client's annual energy costs;
- Savings for individual clients have approached 20 and 30 percent of energy costs;
- Paybacks for recommended improvements have generally been within the three year hurdle adhered to by business for investment;
- The dollar value of EAS recommendations to 75 clients in calendar year 1985 exceeded $11,000,000 annually; and
- Dollar savings identified for individual clients were always well beyond the $400 fee for EAS assistance (by factors from 10 to as much as 10,000).

The Alabama Department of Economic and Community Affairs-Energy Division has established a statewide program relating to the encouragement and promotion of enhanced waste management practices in all sectors of the state's economy. The program began in the late 1970's to educate and motivate various target groups to take action that resulted in improved waste management which was a direct and positive impact on the state's environmental and economic well being.

Three major elements of the waste management programs are:

Solid Waste Recycling and Resource Recovery

Target Group - Individuals, businesses, and industry interested in recycling

Funding Level - $50,000

Energy Savings (Est.) - 60 TBTUs

Used Oil Recovery

Target Group - Do-it-yourself, commercial and government generators of used oil

Funding Level - $55,000

Energy Savings (Est.) - .8 TBTUs

Waste Wood/Biomass Fuel Conversion

Target Group - Industries capable of converting to biomass as a fuel source

Funding Level - $500,000

Energy Savings (Est.) - .3 TBTUs

The New York State Energy Office's Energy Investment Loan Program offers below-market interest rate loans to small industrial and commercial firms, not-for-profit organizations and privately owned apartment buildings, all of which typically lack access to affordable financing or were previously ineligible for government assistance. The Program was operated as a pilot in two areas of the State and has recently been expanded Statewide.

In the pilot program $2.1 million in loans were made to 54 projects in a nine county area. The Energy Office funds are subsidizing the interest to below-market rates. The Energy Office estimates that these projects will save 457,543 gallons of oil equivalent.

ENERGY EXTENSION SERVICES

In Michigan, the Manufacturers' Assistance Program (MAP) is a new service the Energy Administration provides free of charge to small manufacturing businesses that have high energy costs. Started in April 1986, the service is provided to one company each two weeks. Demand for this unique service is so great that publicity has been curtailed after just one newsletter announcement from the Michigan Chamber of Commerce resulted in a four-month backlog of requests. There are approximately 7,000 Michigan companies that could qualify to receive this service based on the limits of size (less that 400 employees) and energy use (greater than $50,000 per year in utility bills), but limited EES funding allows only about two dozen full-service deliveries per year. MAP is the only free service available in the state to get small manufacturers started on the road towards profitable energy savings. The MAP service includes: (1) an energy accounting system used to analyze the company's historical energy costs and to provide a profile of energy use in the facility; (2) assistance reviewing utility billing to identify cost cutting opportunities for demand limiting, power factor controlling, or using different rate structures which are available and (3) a two day on-site analysis to identify opportunities for conservation, more efficient equipment, and new technologies that could be employed in both building and industrial process uses. After these steps are taken, a final report is presented to company management identifying energy saving opportunities. Then assistance is provided in identifying and selecting contractors to perform required modifications, and there is technical assistance for innovative financing techniques including performance contracting.

The Washington Energy Extension Service has targeted farmers in eastern Washington for an extensive tri-State educational effort to improve irrigation system efficiency. The program has reached more than 600 farmers, irrigation equipment dealers, utility and irrigation district personnel through workshops and individual technical assistance. The program produced an irrigation system audit guide, developed a computer program from water scheduling and has worked closely with Idaho and Oregon in sharing expertise, information and cosponsoring joint programs. Response to the programs from farmers and irrigation specialists is very positive, which indicates a strong need for assistance in this sector.

In Maryland the Small Town Energy Education Program (STEEP) is designed to assist small towns in assessing their energy situation and planning and implementing cost effective energy strategies to meet those needs. STEEP has provided thirty towns across Maryland with free energy audits of their municipal buildings, street lighting consulting, water treatment plant energy audits, bulk fuel purchasing information and cogeneration feasibility studies. The key to the extraordinary success of this program is the one-on-one relationship between the town manager or mayor and the Energy Office Staff.

The primary goal of STEEP is assisting small towns in reducing their energy budgets. This goal is particularly important due to the budget difficulties caused by the reductions in federal and state aid. STEEP provides realistic, technically sound information on the towns' energy needs and makes them aware of the resources available to meet those needs. When the resources are not available, the Maryland Energy Office develops the program to help solve the problem. STEEP serves many small towns whose population is under 20,000. Most towns who have participated to date have populations between 2,000 and 8,000. The budget is approximately $65,000 annually and is made up of Federal funding combined with several other sources of funds, including state allocations.

In 1984, the Arkansas Energy Office, in cooperation with the Arkansas Educational Television Network, produced and aired a series of four energy conservation television specials entitled "Home Seasoning." The four-part series offered a simple overview on what to do each season of the year to save money on utility bills. The series was generically produced so that it would apply to most areas of the country and could be used, with very little editing (credits, etc.), by other states. The series was very well accepted by Arkansas audiences, where it has been repeated several times each year since its initial airing.

In 1984, "Home Seasoning" was awarded a bronze medal for educational programming by the International Film and TV Festival of New York.

In the summer of 1986, the Interregional Program Service offered the series, via satellite, to any public broadcasting station wishing to record the series for subsequent airing. At least 35 public broadcasting stations, several of which operate a statewide network, picked up on this award winning series.

In this instance, Energy Extension Service funds, appropriated by Congress for use in Arkansas, served to benefit energy consumers all over the country by introducing to them, via television, common sense ways to save energy throughout the year.

In North Carolina, the Wake County Hospital System embarked upon a phased energy conservation program which to date has resulted in energy conservation measure grants totalling $391,737. Due to limited revenues available through the program, the grant recipient has elected to provide match in excess of the 50% normally provided through the program. To date the hospital has either completed or embarked upon the first three phases of the program and currently has an application pending for cycle IX of ICP. The master plan incorporated within the technical assistance study was developed without the use of Federal funds.

Energy conservation measures funded to date include the following:

Phase 1: Computer based energy management system

Phase 2: Replacement burners on boilers and control upgrade, wastewater heat recovery system for laundry, conversion of air handling units to variable air volume, conversion of operating room air handlers during unoccupied periods.

Phase 3. Integrate steam supply systems for boilers, convert dual duct aid handlers to sequenced air dual duct operation.

Once completed the energy cost savings is estimated at $380,850/year. Simple payback for all measures taken together equals 2.46 years.

In Oregon, Rogue Community College received an ICP grant for several energy conservation projects in 1984. Early in 1985, the college informed the Oregon Department of Energy (DOE) that they could not afford their $37,000 share of the project and would have to drop the idea. But DOE was able to arrange a low interest loan from their Small Scale Energy Loan Program (SELP). This loan program began about two years ago to make low-interest loans to public agencies. These include schools, hospitals, local governments, special districts and state government. The loan program has funded more than $11 million in public sector projects, many of which had engineering studies funded by ICP or its successors. This is just one way DOE has effectively used federal dollars to induce increased local funding.

Over time the college completed projects in 21 buildings. The total cost was $143,000 of which US DOE provided $106,000. The savings were projected to be $15,000 a year. However, four months after completion, the college estimated energy cost savings of $48,000 a year.

In Illinois, Grant Hospital in Chicago received over $630,000 in matching Federal grants to improve its energy efficiency. Once all the measures are installed in Grant Hospital, they are projected to save 10 percent of their electrical consumption and 50 percent of their natural gas usage which amounted to over $1.1 million and $800,000, respectively, over the last year alone.

In Utah, Holy Cross Hospital in Salt Lake City has saved an average of $136,900 annually the past five years after cutting energy consumption more than 31 percent a year. The hospital accomplished this by investing in an overhaul of their energy plant which incorporated some sound "old principles" and new technologies.

Holy Cross received $414,573 from an ICP grand and invested a like amount in the two-and-a-half-year project, which began in the spring of 1980 and ended in the summer of 1982. "We would have implemented the engineer's recommendations over a period of years, but with the ICP funds we were able to accomplish the entire project in half the time", Don Thompson, Hospital Assistant Vice President noted.

By the end of 1986, the project will have paid for itself in reduced energy costs. In terms of the hospital's investment, the project paid for itself almost three years ago.

The project is comprised of four components: 1) a heat recovery system for space heating, 2) a heat recovery system for the laundry, 3) an oxygen trim system on the boiler, and 4) an energy management system. Improving operations and maintenance training and procedures also got top priority.

WEATHERIZATION ASSISTANCE PROGRAM

PROGRAM HISTORY

The Weatherization Program was established by the Energy Conservation and Production Act of 1972, and put under the sole responsibility of DOE in 1979. It was the successor to a CSA-administered program of low-cost grants to low-income households for energy conservation measures.

The program began at $137.5 million in FY 1977. In FY 1982 it received $175 million. That increased to $245 million in FY 1983 and had dropped back to $182 million by FY 1986. FY 1987 funding will be $161 million from a combination of oil overcharge escrow funds and appropriate monies. The FY 1988 budget request is for program close-out.

PURPOSE AND IMPACT

Funds are allocated to the States by a formula. The program specifies the types of materials that can be installed, prescribing standards.

Homes weatherized under this program are typically caulked and insulated; some have storm windows installed and heating systems tuned up, repaired or upgraded.

In most communities, the Weatherization Assistance Program is administered through community--based organizations, usually community action agencies.

A household eligible to receive weatherization is:

1. One whose combined income falls at or below 125 percent of the Federally-established income poverty guidelines; or
2. One which meets eligibility criteria for the Low-Income Home Energy Assistance Program.

The State-wide average expenditure per dwelling for material and related program costs cannot exceed $1,600. In 1985, the average expended was about $1,100.

Many other funds are added by the States to the DOE appropriation and used for the same population, under largely similar rules, through the same delivery system. These include funds from the Energy Assistance Block Grant and from oil overcharge settlements, notable "Warner Amendment" and Exxon case funds. Several large scale utility weatherization programs also utilize the DOE delivery system to provide similar measures to the same population.

Thus, a national survey (by N.A.S.C.S.P.) found that, in FY 1984 and 85, low-income weatherization activity represented $500,000,000 and improved 500,000 units each year.

Annually, national studies show energy savings of between 9% and 37% depending on measures used. By comparison, LIHEAP pays and average of 25% of households energy costs.

NEED FOR FUTURE WEATHERIZATION ASSISTANCE

There were 17.6 million eligible households in 1984. Of these, about seven million currently receive Energy Assistance payments and are therefore already identified as in probable need of weatherization.

Completion of the entire eligible stock at current costs would require over $15 billion in FY 1986 dollars. A more modest goal of completing half the households, with priority to the smaller buildings with which the program is especially successful, would cost just under $8 billion. With the addition of an anticipated $700,000,000 from Exxon funds over 3-5 years, that goal can be achieved in just under 14 years if current federal, state and utility funding is maintained. without the FY 1986 level of federal funding from all sources, this result will not be achieved in this generation.

States' uses of Exxon and Stripper Well allocation may and do vary widely under the court decisions. Some States are spending most of the Exxon funds on weatherization. Many others have allocated little or no funding to this effort. At least ten States have only their federal WAP funding to use in FY 1987. Similar patterns will probable exist in FU 1988, such that DOE funded programs may be all the low income can rely on in a number of states.

Senator **Fowler**. I thank you all for a very good, succinct, even lucid at times, testimony. Mr. Potter describes the fact that we are already in a crisis with our imported energy and our lack of determination to develop a renewable mix to meet the challenges of the next 20, 30 or 40 years.

Mr. Ledbetter, you and Dr. Rosenfeld submit, and I look forward to going through your statements in detail, what you describe as very modest six percent increase in the energy budget. You know there is no such thing as modesty when we have this deficit, realistically speaking, we are going to be fighting to get it up to $80 million, but we won't be up to $170 million in this bugetary climate.

What is it going to take for us to have a national committee? We are at the verge and we have so many demonstrable conservation techniques and techologies that will save us enormous energy bills in the future. Why have we been unable to make the case? Why is it that we await the depths of the crises to act in concert with industry and government together? And do you see any brightness on the horizon that will change our tune, and set a policy that will achieve the kind of goals that we know we can achieve?

Dr. **Rosenfeld**. First I want to emphasize—I am going to give you a two part answer, because all of my 15 minutes was to talk about the need for R&D. The R&D need is a Federal Government response. It is talking about a few tens of millions of dollars for the opportunity 20 years from now to save hundreds of billions of dollars.

Look at the way people look at energy in France. I go to France all the time. I advise the French Department of Energy. When I buy gasoline in France there is a tax of $4.00 a gallon. That means the French pay attention to fuel economy and gasoline. They look forward 10 or 20 years.

A dollar a gallon, incidentally, in this country would bring in $100 billion a year. Two dollars a gallon would bring in $200 billion a year. If you put that into the general fund, you could kill the deficit. You could be reveneue neutral as far as I'm concerned.

Senator **Fowler**. Let me stop you there. Poor President Carter couldn't get 27 votes for a nickle tax on gasoline, so we are not going to do that. I agree with you, not only on your figures, but also on your logic. We're not going to do that.

Dr. **Rosenfeld**. Let me——

Senator **Fowler**. Maybe I interrupted you even though you like to be interrupted.

Dr. **Rosenfeld**. Let me try to give you a piece of ammunition as to how great the market failure is. That is the point we are all discussing. We are just sitting around waiting to go over a waterfall.

In the energy supply business we are perfectly willing to invest in a new power plant or a new oil well and get our money back over like 20 or 30 years. That is the sort of standard time to get your money back on a power plant.

On the demand side we are so short-sighted that we are unwilling in the buildings industry to put in anything which gives you worse than a two year payback, and that even includes federal buildings. Uncle Sam explicitedly turns down the opportunity to make two year payback savings in his new buildings. So the same people who are willing to invest 20 years out on the supply side are not willing to invest on the demand side. Why? Prices are very cheap. We think prices will stay cheap, so we build bad cars and bad buildings because we haven't designed an economic system to recognize that the value of oil and gas and so on are going to go up very soon.

I admit that Mr. Carter couldn't get but 27 votes. Nevertheless, I do want to rub in the point that the Japanese and the French and the Italians and the Germans and so on all pay large taxes on energy, so they think a few years ahead. Despite that, they seem to be doing economically just fine. So we do have a terrible market failure and we have to do something about solving it. That is only very partial answer to your question I guess.

Mr. **Potter**. I wonder if part of our problem in this country may be that for so long we were energy exporters, unlike most of the other countries we have been talking about. For a very long time we were living very high on the hog. We didn't have to worry. Energy came out of a natural cornucopia. It was going to exist forever and it wasn't going to cost anything. That becomes almost a part of the cultural set and it rules us from the grave. It is not true anymore. We know it is not true, but we don't seem to be able to cope with that and to deal with it as a real life change in status which is never going to change again.

Senator **Fowler**. One of the problems is that we said in 1978 or 1979—this was the expected jump in energy prices—that we are going to have $40 per barrel of oil forever, or $60 or $100 barrels, and then all of a sudden it didn't happen. We are back to cheap gas and everybody thinks that we are back to the era of unlimited energy, as you said.

There is no doubt in my mind that if we had $50 or $60 a barrel energy costs right now you, would have taxes on all sorts of things that we have not taxed before in order to develop alternative supplies.

Mr. **Potter**. If you look down the road at fluctuating energy prices, my thesis is that people who are making investments are betting on the bottom side of that investment and they are just not going to take the chance of getting their tails caught in the ringer.

If you take the conservative assumption of prices going up and down and up and down but always watch for the bottom of that curve, you are going to make considerably different judgments than you are if you are looking at it as a phenomenon to a different kind of world than the one that we all grew up in.

Senator **Fowler**. There seems to be a difference in the approach, and it may have been even more acute in our hearings the other day, but it is also echoed today. Tell me where I am wrong between the conservation emphasis, which is basically asking for much more money for research and development, and the renewable energy field, which seems to be asking more for implementation through money for marketing, and taking all this research and development that they have already applied and getting it into the marketplace?

Dr. **Rosenfeld**. If I can say a word about that. There is really no difference in approach. Let's consider transportation. We are going to run out of oil so we are going to need synthetic fuels of some sort. Let me just—I don't know, I am not an expert in this field, but let me assume that we can bring in methynol at $5.00 a gallon. What does that mean? We can't afford to produce that much methynol, even for the present fleet of 26½ miles per gallon. That would be silly. So we will go to where the French are headed now, which is to like 80 miles per gallon.

Then we are on the same side. What do we have to do? We have to learn now to do the R&D so that by the year 2000 we can get to 80 miles per gallon in cars. You can't do it overnight.

In addition, you have to supply the fuel at $5.00 per gallon. We need to do both. We people in conservation are so desparate because of the Federal Government saying you don't even need R&D that all we are doing is standing here pleading for R&D.

Potter is doing something which is actually more noble. He is saying in addition to R&D we need to have something that will help us as Miti helps the Japanese or whatever to actually get demonstration projects, because industrial supply takes longer.

We simply have to do both. We need to pour expensive energy into more efficient devices, so it takes R&D to make the devices more efficient, and then we need to start tuning up and learning how to make photovoltaics and synfuels and so on.

Senator **Fowler**. And you get nobility in the result.

Mr. **Ledbetter**. You started out the question by saying that we have these enormous budget constraints placed on the Congress, and we are just not able to come up with the kind of money that you are asking for. We see the President, the person who is really the lead person on trying to force a reduction, at least he claims he is the lead person in trying to force a reduction in the federal deficit. We see him in the form of his Administration asking that the oil industry be given a $7 billion per year tax break in order to produce an additional one million barrels of oil per day. That is what came out of the letter that Harrington sent to President Reagan. That was in the paper about a week ago. If you do the arithematic on that, that works out to about $19.00 a barrel.

In other words, Secretary Harrington is asking that we subsidize the U.S. industry to the tune of $19.00 a barrel. That is a subsidy in excess of the current world price of oil.

So we see the Administration stepping out there and saying we have a problem and we are willing to spend a huge amount of money in addressing that problem. We think we can address it much more cost effectively if that money is going to be available.

Dr. **Rosenfeld**. Let me rub in that point. If you take the 1975 gas——

Senator **Fowler**. Do you think he minds being interrupted?

Dr. **Rosenfeld**. No. We practiced this. [General laughter.]

If you take te 1975 gas guzzler, 14 miles a gallon, we got it up to 28 miles a gallon and then we backslid a little, but we got to 28 miles a gallon for about another $300 retail. That turns out that the cost of conserving a gallon of gasoline is eight cents. That means if you go to barrels, since there are 42 gallons in a barrel, you are talking about $4.00 a barrel.

Instead of trying to push that and save more energy at $4.00 or $5.00 per barrel, the Administration instead wants to increase supply at $20.00 a barrel. There is something phony with the arithematic. I don't think Ledbetter is going to object to my having said that.

Mr. **Ledbetter**. Not in the least.

Senator **Fowler**. We have had some experience with the so-called experts and their numbers at the Administration.

Mr. **Potter**. Carrying on one additional theme that Art mentioned earlier, remember that before oil prices started dropping all of the experts, whatever that means, were saying yes, the U.S. oil resource base is declining. Nobody has ever suggested that pouring all this money is going to do anything except stick a bigger straw into the ground and suck it out a little bit faster. All we are doing—as I say, we are burning our seed corn. It makes very little sense, except possible as a transition mechanism to get from here to there, but there is no there that has been defined that I understand in terms that the Administration is looking at. All they are trying to do is make the pain go away right now and we will worry about tomorrow the day after tomorrow.

Senator **Fowler**. I appreciate hearing from all of our witnesses. I see Dr. Hubbard and Dr. Blair are still here. Anything you want to add as a postscript?

[No response.]

Senator **Fowler**. We are deeply appreciative, those of us who believe that we can do a far better job on behalf of our nation by the development of alternative energies, that we know how to do it, we can do a better job. We can do it for many of the reasons that were discussed here today. We desparately need a policy if we are going to exercise our public responsibilities to avoid that kind of crisis mentality that we have seen so often in the past. Your testimony and thoughts will go a long way toward taking another step towards that objective.

Mr. **Ledbetter**. Could I ask one question, that is that our Alternative Budget be made a part of the record? I have already given a copy to Ben Cooper.

Senator **Fowler**. It has been. Thank you very much.

[Whereupon, at 4:10 p.m., the hearing was adjourned.]

APPENDIXES

APPENDIX I

Responses to Additional Committee Questions

Department of Energy
Washington, DC 20585

June 23, 1987

Honorable Wyche Fowler
Vice Chairman
Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Vice Chairman:

On March 24, 1987, Donna Fitzpatrick, Assistant Secretary for Conservation and Renewable Energy Programs appeared before the Subcommittee on Energy Research and Development of the Committee on Energy and Natural Resources to discuss the current status of Renewable Energy Technologies.

Following the hearing, you submitted written questions for our response to supplement the record. Enclosed are the answers to those questions, which also have been sent directly to the Committee Staff.

If you have any questions, please have your staff call Roger Sindelar or Tom Todd on 586-4277. They will be happy to assist you.

Sincerely,

J. Thomas Todd
for Robert G. Rabben
Assistant General Counsel
for Legislation

POST-HEARING QUESTIONS AND ANSWERS

Relating to the

MARCH 24,1987 HEARING

Before the

COMMITTEE ON ENERGY AND NATURAL RESOURCES

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

WITNESS: DONNA R. FITZPATRICK

QUESTION FROM SENATOR FOWLER

Question 1a: Plesase provide the Subcommittee with a table showing, for each catagory in the solar and other renewable energy R&D and in the energy conservation R&D budgets, the requests for budget authority for FY 1988 from the program office to the Secretary, from the Secretary to the Office of Management and Budget and from the Administration to Congress.

Answer: The tables are attached.

DEPARTMENT OF ENERGY
FY 1980 CONTROL TABLE
(DOLLARS IN THOUSANDS)

ACCOUNT TITLE	FY 1979 IN FY80 STR B/A	FY 1980 A/S REQ. B/A	FY 1980 OMB REQUEST B/A	FY 1980 CONG. REQ. B/A
ENERGY SUPPLY R&D				
SOLAR ENERGY				
SOLAR BUILDINGS ENERGY SYSTEMS				
OPERATING EXPENSES	5,920	5,250	5,250	5,250
PLANT AND CAPITAL EQUIPMENT	—	150	150	150
TOTAL, SOLAR BUILDING ENERGY SYSTEMS	5,920	5,400	5,400	5,400
PHOTOVOLTAIC ENERGY SYSTEMS				
OPERATING EXPENSES	39,371	24,000	24,000	20,100
PLANT AND CAPITAL EQUIPMENT	1,000	800	870	300
TOTAL, PHOTOVOLTAIC ENERGY SYSTEMS	40,371	24,800	24,870	20,400
SOLAR THERMAL ENERGY SYSTEMS				
OPERATING EXPENSES	22,060	18,000	17,140	14,000
PLANT AND CAPITAL EQUIPMENT	—	—	80	80
TOTAL, SOLAR THERMAL ENERGY SYSTEMS	22,060	18,000	17,220	14,080
BIOFUELS ENERGY SYSTEMS				
OPERATING EXPENSES	23,450	13,585	11,155	10,635
PLANT AND CAPITAL EQUIPMENT	600	415	415	—
TOTAL, BIOFUELS ENERGY SYSTEMS	24,050	14,000	11,570	10,635
WIND ENERGY SYSTEMS				
OPERATING EXPENSES	11,986	12,600	8,100	8,140
PLANT AND CAPITAL EQUIPMENT	4,670	400	400	400
TOTAL, WIND ENERGY SYSTEMS	16,656	13,000	8,500	8,540
OCEAN ENERGY SYSTEMS				
OPERATING EXPENSES	4,474	3,000	3,000	3,000
PLANT AND CAPITAL EQUIPMENT	—	—	—	—
TOTAL, OCEAN ENERGY SYSTEMS	4,474	3,000	3,000	3,000
INTERNATIONAL SOLAR ENERGY PROGRAM				
OPERATING EXPENSES	750	523	523	523
PLANT AND CAPITAL EQUIPMENT	—	—	—	—
TOTAL, INTERNATIONAL SOLAR ENERGY PROGRAM	750	523	523	523

DEPARTMENT OF ENERGY
FY 1988 CONTROL TABLE
(DOLLARS IN THOUSANDS)

ACCOUNT TITLE	FY 1987 IN FY88 STR B/A	FY 1988 A/S REQ. B/A	FY 1988 OMB REQUEST B/A	FY 1988 CONG. REQ. B/A
SOLAR TECHNOLOGY TRANSFER				
OPERATING EXPENSES	2,450	2,090	2,090	2,090
PLANT AND CAPITAL EQUIPMENT	50	—	—	—
TOTAL, SOLAR TECHNOLOGY TRANSFER	2,500	2,090	2,090	2,090
SOLAR ENERGY RESEARCH INSTITUTE				
OPERATING EXPENSES	—	—	—	—
PLANT AND CAPITAL EQUIPMENT	545	1,977	1,100	620
TOTAL, SOLAR ENERGY RESEARCH INSTITUTE	545	1,977	1,100	620
PROGRAM SUPPORT	898	1,337	1,337	937
RESOURCE ASSESSMENT				
OPERATING EXPENSES	600	950	700	700
PLANT AND CAPITAL EQUIPMENT	—	50	20	20
TOTAL, RESOURCE ASSESSMENT	600	1,000	720	720
PROGRAM DIRECTION - OTHER SOLAR ENERGY	4,100	4,830	4,224	4,190
SUBTOTAL, SOLAR ENERGY	123,532	90,085	80,690	71,175
COOPERATIVE VENTURE AND POOLS	—	5,000	5,000	5,000
GEOTHERMAL				
OPERATING EXPENSES	20,830	21,630	19,935	15,935
PLANT AND CAPITAL EQUIPMENT	—	—	26	—
TOTAL, GEOTHERMAL	20,830	21,630	19,961	15,935
HYDROPOWER				
OPERATING EXPENSES	450	63	—	—
PLANT AND CAPITAL EQUIPMENT	—	—	—	—
TOTAL, HYDROPOWER	450	63	—	—
ELECTRIC ENERGY SYSTEMS				
OPERATING EXPENSES	11,276	10,500	7,600	6,500
PLANT AND CAPITAL EQUIPMENT	—	—	—	—
TOTAL, ELECTRIC ENERGY SYSTEMS	11,276	10,500	7,600 a	6,500
ENERGY STORAGE SYSTEMS				
OPERATING EXPENSES	16,509	10,000	10,400	7,474
PLANT AND CAPITAL EQUIPMENT	—	—	26	26
TOTAL, ENERGY STORAGE SYSTEMS	16,509	10,000	10,426	7,500

DEPARTMENT OF ENERGY
FY 1988 CONTROL TABLE
(DOLLARS IN THOUSANDS)

ACCOUNT TITLE	FY 1987 IN FY88 STR B/A	FY 1988 A/S REQ. B/A	FY 1988 OMB REQUEST B/A	FY 1988 CONF. REV. B/A
CONSERVATION				
TRANSPORTATION	56.055	45.206	32.046	22.409
INDUSTRIAL	35.026	33.068	17.972	16.035
BUILDINGS AND COMMUNITY SYSTEMS	30.450	37.453	14.946	14.570
MULTI-SECTOR	20.304	32.271	25.001	20.406
FACILITIES	10.000	—	—	—
COOPERATIVE VENTURE R&D POOLS	—	—	5.000	5.000
POLICY AND MANAGEMENT - CE(EC)	1.062	2.471	1.442	1.442
POLICY ANALYSIS	—	—	—	—
SUBTOTAL, CONSERVATION RESEARCH AND DEVELOPMENT	161.697	150.469	98.227	80.070
STATE AND LOCAL	213.500	9.789	7.789	6.000
SUBTOTAL ENERGY CONSERVATION	375.197	160.238	106.016	86.070
APPROPRIATED TO R&D CS (EC - OE)	—	—	—	—
USE OF PRIOR YEAR BALANCES, EC	-7.510	—	—	—
USE OF FY86 DEFERRAL - (CE)EC	—	—	—	—
SAVINGS FROM MANAGEMENT INITIATIVES - (CE)EC R&D	—	—	—	—
PETROLEUM OVERCHARGE (PODRA)	-138.067	—	—	—
REMAINING INDEFINITE APPROPRIATION	46.517	—	696	—
EMPLOYMENT FLOORS/FTES	—	—	-5.000	—
COOPERATIVE VENTURE R&D POOLS-CE	—	—	—	—
RESCISSIONS & REDUCTIONS TO INDEFINITE APPROP.	-130.450	—	—	—
TOTAL, ENERGY CONSERVATION	149.679	160.238	101.712	86.070

DEPARTMENT OF ENERGY
FY 1988 CONTROL TABLE
(DOLLARS IN THOUSANDS)

ACCOUNT TITLE	FY 1987 IN FY88 STR B/A	FY 1988 A/S REQ. B/A	FY 1988 OMB REQUEST B/A	FY 1988 COND. REQ. B/A
GEOTHERMAL RESOURCES				
GEOTHERMAL RESOURCES DEVELOPMENT FUND.................	72	72	76	72
TOTAL, GEOTHERMAL RESOURCES.............................	72	72	76	72

QUESTION FROM SEANTOR FOWLER

Question 1b: Please comment on the Alternative Energy Conservation Research and Development Budget submitted for the Subcommittee hearing record by the American Council for an Energy-Efficient Economy.

Answer: The alternative budget assumes the FY 87 appropriation level as a starting point, without any consideration of whether items within that funding should be continued. Some projects being funded in FY 87 are scheduled for completion this year and others are of dubious value, such as the Automotive Stirling Engine and the Tufts University building. The budget includes a number of often vague new initiatives to increase the current FY 87 budget by 15 percent. Many of these initiatives were raised and discussed in developing the Conservation Multi-Year Plan for FY 88-92. The Alternative Budget is inconsistent with present program priorities and is often inconsistent with efforts to help reduce the Federal budget deficit. Often it represents a shopping list of new projects for special interests which we do not believe are in the national interest.

The proposed Conservation budget request reflects our best judgment as to how we can maximize our resources to advance the state of the art in energy-efficient technologies while at the same time contributing to the Congressional and Administration goal of reducing the federal budget deficit.

QUESTION FROM SENATOR FOWLER

RENEWABLE ENERGY BUDGET

Question 1(c): Under the budget you have proposed, how do new ideas receive support?

Answer: While the Conservation and Renewable Energy budget requests are focussed on the highest priority research needs, methods exist to provide for funding of new ideas and innovative concepts. Notable examples include:

- CE participation in the Small Business Innovative Research program. CE topics have been included in each annual solicitation, have attracted a number of highly innovative proposals from industry, have resulted in funding for a number of these proposals, and have resulted in several projects being incorporated into subsequent program project funding plans.
- Solar Thermal
  - New ideas are identified through multiyear program planning efforts where new ideas are solicited and evaluated. Yearly public solicitations for Letter of Interest (LOI) and Program Research and Development Announcements (PRDA) invite and support the participation of private industry, university researchers, and the solar thermal community to recommend

promising concepts and applications for the program. Following the exploratory research phase, those concepts showing the most promise are funded for further development.

- Solar Buildings
  - Annual PRDA's issued to solicit proposals to develop innovative concepts in building materials, subsystems, and systems which offer opportunities for significant improvements in the contribution of solar energy to building requirements.
- Geothermal
  - A Geothermal drilling industry organization has been formed for collaborative cost-shared activities with DOE to fund prototypical hard rock penetration R&D.
- Photovoltaics
  - An annual university procurement has been established to explore new concepts, to broaden the photovoltaic knowledge base, and to expand the number of photovoltaic-trained technical graduates.
- Cooperative R&D Ventures
  - The Department is soliciting interest in a program to support industry formed

cooperative R&D ventures. This will provide the opportunity to leverage federal funds with industry funding to pursue R&D initiatives.

- Energy Conversion and Utilization Technologies (ECUT)
  - The ECUT program conducts long-term, high risk research of a generic type which can be applied to more than one of the end-use sector research programs in transportation, industry and buildings. ECUT also evaluates and, as appropriate, investigates new or innovative concepts for improved efficiency or alternative fuel use in conversion systems or utilizing devices. ECUT, therefore, serves as a conduit for the introduction of new concepts into the overall Conservation research program at the level of the most fundamental principles with the potential for wide impacts across all sectors of energy use.

- Energy-Related Inventions Program (ERIP)
  - From inventors and small businesses the ERIP receives freely submitted applications requesting support for the development of

thousands of inventions each year. The National Bureau of Standards (NBS) evaluates each application to determine the technical feasibility and energy-related benefits of each invention. NBS then recommends the most promising inventions to DOE for financial wide-ranging assistance in an effort to ensure the introduction of these new and promising technologies into the marketplace. ERIP has supported the development of over 300 inventions of which 73 have now generated sales of over $200 million.

QUESTIONS FROM SENATOR FOWLER

RENEWABLE ENERGY - U.S. PERFORMANCE

Question 2a: Discuss the performance of U.S. firms in world trade in photovoltaic, solar thermal, and wind energy technology. What have we done right and what have we done wrong?

Answer: As other nations mirrored U.S. actions and initiated research programs in renewable energy technologies, the overwhelming dominance in worldwide sales by the U. S. in the 1970's inevitably receded. Nevertheless, for most renewable technologies, U. S. firms still retain a 1/3 to 2/3 share of world markets. Photovoltaics and wind are at the lower end of this range. However, within the photovoltaic power generation market segment, which has the largest growth potential, the U.S. has over a 50% market share. Solar thermal sales are dominated by a single Israeli firm, but significant participation by its U.S. subsidiary gives the U.S. a position in the midpoint of the range. According to most market forecasts, today's renewable energy sales are a tiny fraction of the ultimate potential. Current market positions are not necessarily indicative of future market share. It is future advanced technologies that will establish meaningful market leadership and that will permit a measure of the "right" or "wrong" of today's actions. The U.S. technology base is generally regarded as the world leader with regard to state-of-the-art across the board and industry should benefit from the breadth and depth of U.S. research in future competition for commercial markets.

QUESTIONS FROM SENATOR FOWLER

RENEWABLE ENERGY - U.S. PERFORMANCE

Question 2b: What role has our renewable energy research and development played in our success or failure in world markets for these technologies? How have our R&D programs helped? Where have they failed?

Answer: Results from DOE supported renewable energy R&D programs help U.S. firms manufacture products that are increasingly competitive. These R&D programs have helped in understanding the basic science and engineering associated with the various technologies. The technology base continues to progress and each year a greater variety of U.S. power needs are being satisfied. For many international energy needs that can be served by current technologies, a major problem continues to be accessing markets. By and large these markets consist of small remote power needs in countries where financing is a real impediment. While market development is the responsibility of commercial organizations, the Department of Energy, in its participation in the Committee on Renewable Energy Commerce and Trade (CORECT), is supporting industry efforts in this regard.

QUESTIONS FROM SENATOR FOWLER

RENEWABLE ENERGY - U.S. PERFORMANCE

Question 2c: What is the trade potential and the energy supply potential of renewable energy technologies:

- solar thermal?
- photovoltaics?
- wind?
- other technologies?

Evaluate the position of U.S. firms seeking to compete in each of these markets and what DOE is doing to help.

Answer: Significant foreign market potential exists for many of the domestic renewable energy industries. This results principally from two intermeshing factors, (1) that an estimated 1.7 billion people in developing areas of the world do not have access to a power source for basic human needs and economic development, and (2) that many renewable technologies are economically competitive today in remote non-grid connected applications. For example, solar thermal has been consistently identified as having major potential applications in Middle Eastern and Pacific Basin areas and, more recently, in the Caribbean. Photovoltaics is a prime candidate for use by virtually all the less developed countries in stand-alone applications such as communications, village power and lighting, and water pumping. In both wind farms and single dispersed units, windpower could contribute substantially in Europe, India, Central America, the Carbbean, and Pacific Island countries. Potential markets for geothermal have been identified in the Phillippines, Mexico, and Indonesia, and biomass energy products could be produced in nearly all inhabited areas of the globe.

In pursuing world markets in the renewable technology areas, U.S. firms are competitively equal to or superior to those in other nations. For today's small but growing markets, the Committee on Renewable Energy Commerce and Trade (CORECT), a Federal interagency group, provides information and assistance to U. S. export-seeking companies. To assure major future market shares for the U.S., ongoing research programs to attain more advanced technology are the most important present day investment.

QUESTIONS FROM SENATOR FOWLER

RENEWABLE ENERGY - U.S. PERFORMANCE

Question 2d: At the hearing on both the 24th and 26th the Subcommittee received testimony indicating quite emphatically that many U.S. firms involved in photovoltaics and in wind energy are in very bad shape and may suffer further erosion in sales. Testimony on the 26th from the Office of Technology Assessment predicted that very few renewable energy technologies appear likely to be deployed extensively in the 1990's" (p.3, testimony of Peter D. Blair). What are the Administration's plans to reverse these current trends?

Answer: Throughout the late 1970s and the 1980s the U.S. photovoltaic industry has been characterized by dropouts of some firms and entry of others. This is, in our view, a normal occurrence during the early development stages of any new industry.

In contrast, there has been a sharp decline in the number of firms manufacturing wind turbines, a consequence of the expiration of Federal tax credits and the artifically stimulated entry of new firms during the tax credit years. The appropriate Federal action for both photovoltaics and wind is the continued support of research to provide advanced technology that helps industry develop and make available fully competitive energy systems in a free energy marketplace.

QUESTION FROM SENATOR FOWLER

RENEWABLE ENERGY PRIORITIES

Question 3(a): Should the U.S. put more of its limited research and development dollars behind a few technologies and projects that offer the best promise to be cost effective and exclude others? How should we pick these technologies?

Answer: By sustaining a balanced effort among renewable energy technology options, we believe our budget request is prudent in providing momentum across the technology spectrum. Ultimately, the private sector is best equipped to select specific renewable energy technologies for commercialization. Our best judgment is that each of the technologies included in the DOE program exhibits worthwhile promise and that our requests will provide the scientific and technical momentum necessary to establish viability of renewable energy concepts as energy supply options over the next decade.

QUESTION FROM SENATOR FOWLER

RENEWABLE ENERGY PRIORITIES

Question 3(b): What is the justification for supporting only long-range, high-risk research in renewable energy and energy conservation technologies and not supporting development and demonstration efforts to bring technologies to the point of commercialization?

Answer: Research and development of energy technologies usually advance through successive phases: basic research, applied research, proof-of-concept, process development, and commercialization. At each phase, a judgment must be made about the level and pace of Federal support. At each phase, progressively larger investments of money and talent are required, with funding requirements increasing most sharply in the later phases of large-scale demonstration plants and commercialization. These same later phases are also the points at which private industry can estimate the potential for proprietary profits from the technology, and can make rationale decisions based on expected return on investment.

This Administration's policy from the start was to focus on the earlier phases of the process, calling on the market to determine the economic feasiblity of the later, more expensive phases. This approach enhances Federal flexibility and responsiveness. History has shown that the Federal Government does not have the necessary expertise, motivation, and approach to do the best job of selecting the exact mix of technologies that will finally gain market acceptance.

The types of R&D represented in our FY 1988 request are considered fundamental to establishing the scientific and technical base necessary for industry to deploy these technologies in the upcoming decade. The activities proposed for funding will advance renewable energy on a broad scale and should have general industrial payoffs while avoiding high cost demonstrations, which typically benefit single industrial interests.

Our research efforts should contribute to our Nation's productivity by broadening our understanding of fundamental processes and by adding to the available technological base.

This, in turn, is likely to continue laying groundwork for improved or new energy technologies to be developed by the private sector.

QUESTION FROM SENATOR FOWLER

RENEWABLE ENERGY PRIORITIES

Question 3(c): Is there evidence that sufficient support for development and demonstration activities will be forthcoming from non-Federal sources? Please discuss your policy in light of this evidence.

Answer: We are currently able to secure industrial participation in our research activities. It will take a number of years to overcome the remaining technical and scientific challenges. We will carefully monitor over the upcoming years the engineering development and commercial activities of industry as the technologies evolve to the point to warrant industry undertaking the challenges of commercial development.

QUESTION FROM SENATOR FOWLER

RENEWABLE ENERGY PRIORITIES

Question 3d: Some of the testimony received at the hearings indicated that DOE is unwilling to support research that firms in the industry believe is necessary. Examples, in the case of photovoltaic research, include the development of manufacturing technology and conducting experiments on the scale that is of interest to electric utilities. Is this true? Please explain how you obtain information from firms about what research, development and demonstration is needed and how you decide what advice to follow and what to reject.

Answer: In renewable energy, as in most activities, it is not possible to obtain from industry unanimity on what research should be supported. For instance, PV manufacturers and the utilities may disagree about the value of demonstration projects. Major PV community input occurs when programs prepare five-year research plans in cooperation with industry and universities. In addition, the programs interact in yearly workshops and conferences with a broad representation from industry as well as from universities to discuss latest findings, plans, and recommendations for work to be performed in the near future. From these interactions, the DOE selects those fundamental approaches that will help build a strong science-based U.S. industry. Demonstrations and manufacturing research are tied to the operational requirements, preferred practices and processes, and business strategies of individual companies and are, therefore, inappropriate for federal support.

QUESTION FROM SENATOR FOWLER

RENEWABLE ENERGY PRIORITIES

Question 3(e): If Congress directed you to devote a share of available appropriations to development and demonstration work in renewable energy technologies and provided level funding for the program as a whole relative to FY 1987, how would you allocate this money among various efforts:

Answer: Although we do not believe that such expenditures are in general the most effective way to achieve our national energy objectives, we would, of course, carry out the requirements of law and make every effort to obtain maximum benefit from the expenditures. Our first priority would be to fund those projects specifically designated by law. Next, the Department would examine proposals on a case by case basis in light of a number of factors including the contribution of such a proposal to multi-year technology objectives as established in Multiyear Program Plans; the degree of risk entailed in such a proposal; the degree that the private sector was willing to tangibly share in undertaking the technical and financial risks; the potential of the proposal to substantially advance the state-of-the-art; and the degree of industry-wide benefit versus benefit to an individual participant. On balance, the Department would prefer to work with the Congress to ensure that funds are allocated to more basic research of broad industry payoff and most capable of overcoming the primary remaining scientific and technical challenges in renewable energy.

QUESTION FROM SENATOR FOWLER

RENEWABLE ENERGY PRIORITIES

Question 3(f): What renewable energy and energy conservation technologies could benefit in the near term from proof-of-concept demonstrations. Please discuss your answer, including estimated costs.

Answer: The Conservation and Renewable Energy technologies undergoing DOE sponsored R&D show considerable promise for contributing to the Nation's future energy supply mix. In most instances the scientific and technical efficacy of these technologies has been established by prior research efforts and the research programs of the next several years are aimed at fostering economic viability in the upcoming decade. The Department does not believe that there is a technical need for demonstration of these technologies at the present time. As the technologies approach economic viability over the next several years, the private sector should be prepared to undertake demonstrations within the context of the commercial marketplace.

QUESTIONS FROM SENATOR FOWLER

RENEWABLE ENERGY MECHANISMS

Question 4: Provide your views on the advantages and disadvantages of the following mechanisms for supporting the development of renewable energy and energy conservation technologies. Which mechanisms would you support?

(a) Financing concessions through low-income loans.

(b) Federal procurement.

(c) Tax credits.

(d) Export assistance.

(e) Expanded opportunities for renewable energy facilities to become qualifying facilities under the Public Utilities Regulatory Policies Act.

Answer: The Department believes that continuing the momentum towards removing Federal decisionmaking from the affairs of the commercial marketplace, coupled with other initiatives to foster industrial risk taking and innovation represent the best general policy for realizing the economic future of these technologies. As such, mechanisms to provide targeted subsidies or other direct assistance to individual interests are generally unproductive and will limit the long term viability of the technologies. The specific mechanisms posed by the question are viewed as follows:

(a) Financing concessions through low-income loans. While potentially effective in subsidizing installation of conservation and renewable energy technology, this mechanism has the potential for diverting resources away from more economic opportunities (including low cost conservation), due to distortion of normal price mechanisms, and away from other high priority basic needs of low-income persons.

(b) Federal procurement. The Department supports Federal procurement of Conservation and Renewable Energy technology where cost effective and where technology reliability is consistent with operational needs. This mechanism would benefit accomplishment of Government missions through contributing to energy supply security and stability, and would contribute to taxpayer interests through reducing operating expenses for one of the Nation's larger energy consumers. Subsidizing the installation of inefficient energy systems through Federal purchases at taxpayer expense would constitute an inappropriate Federal policy. Effective implementation of this policy with respect to energy efficiency is described in OMB Office of Federal Procurement Policy letter 76-1, later incorporated into the Federal Acquisition Regulations (48 CFR, Chapter 41, Subpart 23.2) which notes in part, that "......Whenever the results would be meaningful, practical, and consistent with agency programs and needs, agencies shall apply energy conservation and efficiency criteria to acquisitions. In preparing solicitations and evaluating and selecting offers for award, agencies shall consider these criteria along with price and other relevant factors."

(c) Tax credits. This mechanism would contribute to installation of additional quantities of conservation and renewable energy equipment. The price distortion attendant to subsidizing specific interests through the tax code has a clear potential to result in installation of economically inefficient technology; may divert capital from more cost effective investments including alternative energy technology; may result in artificial discrimination against taxpayers not able to take advantage of incentives; may stimulate installation of lower quality systems opportunistically tied to tax incentives rather than the economic interest of consumers which we have already seen in both solar domestic hot water heaters and some wind farms; may retard the rate of technology evolution; may divert capital away from other basic needs and services; and thereby has the potential to undermine general productivity and competitiveness within the economy.

(d) Export assistance. This mechanism has the potential to assist domestic industry in evaluating and securing foreign markets. Subsidization of technology exports might temporarily stimulate industrial exports but at the expense of more productive investments in the economy and at the risk of escalation of foreign interventionist policies which could serve to undermine national and global productivity. Conservation technology and industry interests are sufficiently established that Federal programs would duplicate the capability and activities of the private sector. In the case of renewable energy, the Department is collaborating with a number of domestic agencies and lending organizations through the Committee on Renewable Energy Commerce and Trade to utilize existing authorities to establish competitive access to valuable foreign markets.

QUESTION FROM SENATOR FOWLER

RENEWABLE ENERGY POWER APPLICATIONS

Question 5(a): What research does DOE conduct to integrate renewable energy technologies into electric supply power systems?

Answer: DOE conducts research in a variety of areas to better understand and solve problems in the integration of renewable energy technology into electric supply systems. In the Energy Storage and Distribution program, the activity Automation/Processing Concepts addresses communication and control needs for utilizing varied power sources. This research will allow the most effective use of photovoltaic, wind, ocean, solar thermal, biofuels, and municipal waste technologies in the electric grid. In addition, electrochemical and thermal storage will provide means of better matching diurnal, weekly, and seasonal supplies and demands and meeting qualitative requirements of utilities for sources of power.

In the Solar Electric program, DOE addresses needs and requirements for integration into electric utilities.

In the DOE Wind program, for example, cooperative testing of the Westinghouse wind farm of 600 kW turbines, owned by the Hawaiian Electric Industries (parent company of the local utility), is done at Kahuku Point on Oahu. The 3.2 MW Mod-5B will be purchased from the government by Hawaiian Electric Industries; it is now being erected at Kahuku Point. It will be the Nation's first MW-scale variable-speed wind turbine and will provide electrical data, as well as assist in validating aerodynamic and structural models. The variable nature of the wind is a frequent concern expressed by utilities, and we have a research project with the Hawaiian Natural Energy Laboratory and the Hawaiian Electric Company to address wind farm issues related to high penetration on weak utility lines. Baseline data are now being taken on the island of Hawaii. Key parameters include voltage and power profiles, reactive power demands, methods of control, all as a function of wind conditions. Integration of wind turbines with diesel generators is also an object of research, because experience has shown that there is difficulty in tying a wind turbine with a diesel generator system to achieve an economic marriage. This work is aimed at helping small utility systems.

QUESTION FROM SENATOR FOWLER

RENEWABLE ENERGY POWER APPLICATIONS

Question 5(b):	What research is done to assist in obtaining penetration of the U.S. utility market?
Answer:	DOE carries out research activities, coordinates with utility groups, provides information to utilities, and has funded research relating to integration of renewables into electric utilities.

DOE has funded the operation of Design Assistance Centers which provide technical assistance to communities, cities, and utilities. A center for Wind at the Solar Energy Research Institute and a center for Photovoltaics at Sandia National Laboratories help potential users understand the needs of the renewable technology and develop specifications for the procurement of new systems. In addition, technical experts provide assistance during installation and start-up and periodically help in monitoring operation to identify potential problems.

DOE coordinates research activities with the Electric Power Research Institute (EPRI) to avoid duplication of effort and to ensure that the results of new technology and system needs for renewable technology are shared with electric utilities throughout the U.S. DOE worked with EPRI to develop the concept of the Power Electronics Applications Center in Tennessee. This Center will be closely tied to industry and will investigate power systems components and operations. DOE has agreed to provide expertise to help the Center become established. It is expected that the Center will be beneficial in accelerating the penetration of renewable energy technology into utility grids.

DOE provides information through reports, conferences, technical meetings, workshops, personal contacts, and other publications on the results of R&D activities. This information is important in assisting transfer of new technology.

QUESTIONS FROM SENATOR FOWLER

RENEWABLE ENERGY POWER APPLICATIONS

Question 5c: Please assess the status and prospects of the U.S. photovoltaic industry in achieving a higher share of U.S. and foreign markets for electric power. You were quite optimistic at the hearing, but all other witnesses who addressed this issue were pessimistic. Please explain.

Answer: The U.S. industry controls nearly 100% of the U. S. photovoltaic power market. We would agree that the high cost of photovoltaic systems and the environment of low oil prices and other deterrants to long-term investment are discourgaging factors for the short term. But they are temporary. From industry's own data it is clear that U.S. photovoltaic manufacturing easily leads the world in sales to the power market. Shipments from U.S. firms are estimated to be double that of the nearest competitor. Further, we believe that at the current exchange rate U.S. modules are priced competitively with all foreign modules and the quality of U.S. modules is equal or superior. The U.S. systems design capability is, for the most part, superior. Under these conditions, we believe that the U.S. industry will maintain its leadership in the power market.

QUESTIONS FROM SENATOR FOWLER

MOD-5B WIND TURBINE PROJECT

Question 6:	The Mod-5B Advanced Multimegawatt turbine has very nearly completed its testing. Why? What is the status of this machine and the arrangement with Hawaiian Electric Industries involving this machine?
Answer:	Fabrication of the Mod-5B Advanced Multimegawatt turbine parts was completed and shipment made to the island of Oahu during December 1986. Assembly of the turbine is now in progress at Kahuku Point, Oahu. Lift of the nacelle and rotor to the top of its tower is planned for early May 1987 and first rotation for July 1987. This will be followed by operational checkout of the machine. There may be a further period of acceptance testing by the utility. At the completion of testing, the Mod-5B would be available for sale to Hawaiian Electric Industries.

QUESTION FROM SENATOR FOWLER

Question: What guidance have you received from the Energy Research Advisory Board in strategy for developing renewable energy and energy conservation technologies? How have you followed this advice?

Answer: ERAB has long recognized the importance of developing new conservation technologies and contributing towards improving efficient end use. CE reviews and responds to all ERAB recommendations. For example, we carefully reviewed and responded to the recommendations in their "Long-Range Civilian R&D Guidelines Report." They have encouraged efforts in fundamental research and on generic long-term technology development. CE has consistently supported funding for the Office of Energy Utilization Research which pursues a range of cross-cutting research to establish fundamental knowledge in materials science, tribology, biocatalysis, and combustion reseach which can lead to significant energy efficiency improvements.

We believe that we are generally folowing their advice and we are attempting to work closely with ERAB in the Energy Competitiveness Study which is currently underway.

QUESTIONS FROM SENATOR DOMENICI

RENEWABLE ENERGY PROGRAMS

Question 1:	If Congress were to take some action to help foster renewable energy programs, what action do you think would have the most beneficial effect on our industry: (a) provide more money for research and development, or (b) provide market and manufacturing incentives such as tax credits, accelerated depreciation, manpower training, etc.?
Answer:	The Department has no proposals to offer at the present time. I should note, however, that it is our view that Federal support to commercial or near commercial activities tends to compete with the capabilities of the private sector and involves a number of negative aspects frequently not intended by sponsors of the incentive. The role most suited to Federal support concerns the funding of research -- which also represents the key to realizing the economic promise of the conservation and renewable energy technologies.

QUESTIONS FROM SENATOR DOMENICI

RENEWABLE ENERGY PROGRAMS

Question 2: Why is it the foreign countries like Japan can so easily avail themselves of the renewable energy technology that has been developed in this country? Is the reverse situation true, that is, do we have easy access to technologies developed abroad? If not, what can we do to better protect our investments?

Answer: The American economy, much like the rest of its society, has been extraordinarily open since its inception. The openness has extended from civil liberties, to education, to science and technology. Within this environment the domestic industry has established a pace of accomplishment and innovation virtually unmatched by any other country. A by-product of this success is that prospective competitors have sought access to our technological knowledge. Gaining access to technical data and information may be easier in the United States than in many of these other nations, even when such information exists. In order to better protect our investments the Secretary has established a task force to investigate methods to protect intellectual property and technical data developed with DOE funding. This effort is currently underway.

Assisted by Administration initiatives to open international markets to increased competition, the domestic industry is moving with new vitality to compete more successfully in global markets, including energy. It is worth noting that in our R&D collaborations with foreign nations, the Conservation and Renewable Energy organization will only participate where an opportunity for mutual technological benefit exists. Through DOE-sponsored R&D collaboration, the domestic industry is able to supplement domestic public or privately funded research with innovations developed abroad. The Department is also assisting industry in obtaining other difficult to acquire information, such as equipment specifications or market data from avenues available through the Committee on Renewable Energy Commerce and Trade interagency effort. Finally, access to foreign technical reports is picking up as a result of services provided by the Office of Science and Technology Information (OSTI) which include obtaining and translating technical reports, papers, and articles.

QUESTIONS FROM SENATOR DOMENICI

RENEWABLE ENERGY PROGRAMS

Question 3: To what extent do you feel that the lower of the dollar value will help U.S. competitiveness in renewables?

Answer: Domestic or international competitiveness of the renewable energy technologies is affected by a large number of economic factors including the value of the dollar, the relative cost of capital, general economic activity, and the cost and availability of conventional energy supplies. A short-term improvement in the relative value of the dollar could provide for short-term improvement in the relative competitiveness of domestic technology to the extent that the technology is sufficiently mature and economic. Short-term fluctuations in the dollar will have little effect on the viability the technologies currently undergoing R&D. These technologies are proceeding in accordance with multiyear plans aimed at achieving economic competitiveness over the upcoming decade.

QUESTIONS FROM SENATOR DOMENICI

RENEWABLE ENERGY PROGRAMS

Question 4:	How effective do you think DOE's technology transfer efforts are? Is there room for improvement?
Answer:	The technology transfer efforts to date have been quite effective within the area of renewable energy. As the program thrust is primarily research and development for application in the private sector, rather than commercialization and outreach, successful evidence of technology transfer is less apparent to the general public than it is to the research communities. Efforts are continually occurring within all renewable energy technologies to exchange information through such mechanisms as (1) collaborative research, (2) cost-shared contracts, (3) technical assistance, (4) publications and scientific papers, (5) advisory boards and technical committees, and (6) fostering visiting research staff at DOE laboratories. We continually review the dialog to ensure that we and the research communities within our technologies are doing everything reasonably possible to transfer information regarding their efforts. We will continue to review these activities with an eye toward continued refinements and improvements.

QUESTIONS FROM SENATOR HECHT

ENERGY INFORMATION

Question 1: In the recently released Energy Security Study section on renewable Energy, it states that in order for renewable energy to play a viable role in energy security it will have to grow. I am particularly interested in geothermal energy. The report also states that renewable energy cannot grow enough to have an impact in the next decade because additional research is required. A projected 84 percent increase in renewable energy's share of the total world energy supply over the next 30 years would bring renewables' contribution from 9 to 12 percent. Does the current R&D budget for the geothermal technologies portion provide for the growth necessary to achieve the Administration's objectives?

Answer: The President's budget does provide sufficient funding for the technical advance necessary to achieve program objectives in geothermal energy. The President's budget includes a mixture of near-term and long-term research to provide the technology base necessary for the private sector to develop geothermal energy.

QUESTIONS FROM SENATOR HECHT

ENERGY INFORMATION

Question 2: What geothermal technologies should be encouraged with Federal R&D funds? Would you support additional funding for renewable energy R&D, particularly geothermal energy? What role do you believe geothermal energy can play in our national security?

Answer: The Department is involved in both near-term (hydrothermal) and long-term (hot dry rock, geopressured, magma) research in geothermal technologies. It is our belief that the program requested in the President's budget is sufficient to achieve the planned objectives for these geothermal technologies. Currently there are 2,000 megawatts on-line from geothermal facilities in the western United States, and the Electric Power Research Institute (EPRI) has recently estimated that 8,000 megawatts will be on-line by the year 2000. Geothermal energy is an indigenous form of energy that enhances the nation's energy security and helps reduce foreign oil imports.

QUESTIONS FROM SENATOR HECHT

ENERGY INFORMATION

Question 3:	Are the funds currently appropriated for geothermal R&D earmarked for research in technologies where it will be most helpful to the industry and national energy security goals?
Answer:	Yes. All research in hydrothermal energy is done with the advice of industry. The hot dry rock, magma, and geopressured programs frequently consult with industry to ensure that research is conducted to maximize the benefits to industry. Hydrothermal, hot dry rock, and magma will help provide stable supplies of electrical energy, while geopressured will help provide a stable supply of natural gas and electrical energy.

QUESTIONS FROM SENATOR HECHT

ENERGY INFORMATION

Question 4: Has the department heard recommendations from geothermal industry representatives and were those recommendations reflected in its budget request? What amount did industry recommend for FY'88 and in what areas of research?

Answer: The Department meets frequently with representatives of industry at program reviews and industry-government panel sessions. Also the Department's field offices and the national laboratories have close contacts with industry. At a program review meeting held at Los Alamos in November 1986, industry recommended that $34.7 million be provided to the geothermal program in FY 1988, distributed among hydrothermal, hot dry rock, geopressured, and magma.

The Administration recommended that $15.9 million be provided, as the amount considered to be sufficient to meet the Administration's objectives which are balanced across longer term technology needs as well as the nearer term hydrothermal priorities which were the focus of industry interest in the recent program review.

QUESTIONS FROM SENATOR HECHT

ENERGY INFORMATION

Question 5: Currently, are there enough other Federal programs in place to encourage the development of renewable energy resources? For example, a number of tax incentives for geothermal and other renewable energy resources are being phased out as a result of the Tax Reform Act of 1986. Do you believe the Congress should encourage those types of incentives for development of renewable resources?

Answer: Under the Tax Reform Act of 1986, there have been changes in tax credits and depreciation schedules for renewable energy resources. These changes tend to make investment in geothermal energy properties more attractive. However, when combined with reduction in investor tax brackets, the net effect can be neutral. While tax incentives could be helpful in the short-term for establishing emerging technologies, the technologies should be able to compete long-term on their own merits. We have also seen that many efforts to stimulate technologies with tax credits have had unintended, and detrimental side effects. In general, tax subsidies tend to keep prices unnecessarily high and delay improvements in technologies because they protect the industry from competition.

QUESTION FROM SENATOR FOWLER

Question 5: With respect to conservation efforts, do you think state and federal efficiency standards have been effective in promoting greater conservation? Is the imposition of efficiency standards as effective as Federal support for R&D?

Answer: Federal energy efficiency standards have only just been established for major household appliances and are not yet in place for building performance. Although various states have imposed standards, their effectiveness insofar as energy conservation is concerned is not clear. It is generally believed, however, that these standards have reduced energy consumption to some extent by limiting the availability of low-efficiency appliances.

Between 1974 and 1984 per capita household energy use fell 11.5 percent and between 1972 and 1984 the average energy efficiency of new appliances increased significantly, 71 percent for refrigerators, 59 percent for freezers and 55 percent for clothes washers. It is difficult to attribute much of these gains to efficiency standards, because there were no federal standards and only a few state standards in effect during that time. Evidently, the improvements were largely market responses to higher energy costs and greater energy awareness among consumers and manufacturers.

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ROGER G. LITTLE
President

6 April 1987

Mr. Wyche Fowler, Jr.
United States Senate
Committee on Energy and Natural Resources
Washington, DC 20510

Dear Mr. Fowler:

Thank you for having given me the opportunity to appear before the Subcommittee on Energy Research and Development on March 24, 1987. I have received your follow-up questions. Answers are enclosed.

The time is now for cooperative industry-government activity to enhance Americas competitiveness in the world. Photovoltaics is an ideal vehicle for this.

Sincerely,

SPIRE CORPORATION

Roger G. Little
Roger G. Little

RGL/ml

Enclosure

PATRIOTS PARK / BEDFORD, MASSACHUSETTS 01730 / 617-275-6000

March 24 and
March 26 Renewable Hearing

QUESTIONS

Submitted by Senator Domenici

1. If Congress were to take some action to help foster renewable energy programs, what action do you think would have the most beneficial effect on our industry: (a) provide more money for research and development, or (b) provide market and manufacturing incentives such as tax credits, accelerated depreciation, manpower training, etc.?

2. Why is it that foreign countries like Japan can so easily avail themselves of the renewable energy technology that has been developed in this country? Is the reverse situation true, that is, do we have easy access to technologies developed abroad? If not, what can we do to better protect our investments?

3. To what extent do you feel that the lowering of the dollar value will help U.S. competitiveness in renewables?

4. How effective do you think DOE's technology transfer efforts are? Is there room for improvement?

5. With respect to conservation efforts, do you think state and federal efficiency standards have been effective in promoting greater conservation? Is the imposition of efficiency standards as effective as federal support for R&D?

Responses
To Questions Submitted by Senator Domenici

1. I recommend that Congress take action to provide more money for research and development in order to further foster photovoltaics. Although considerable technical progress has been made, much more needs to be done in order to reduce the cost of photovoltaic products to compete with other energy sources in large scale applications world wide. In addition, I believe that serious consideration should be given to a major national initiative to establish distributed manufacturing plants for photovoltaic modules to create jobs and energy. Large scale distributed manufacturing has the potential of achieving very low manufacturing cost. The photovoltaic modules produced can be used by local utilities. Excess product can then be shipped internationally.

2. Japan is our principal competitor in photovoltaics. The Japanese have made available to themselves U.S. renewable energy technology, principally through its students. As is well known, the Japanese send their students to our universities throughout America. These students return to Japan with our technology and compete with us. I believe it's time for America to take steps to discourage taking our technology base in this manner. A specific recommendation I have is that all foreign students be made to pay five times the tuition of U.S. students at all universities. We must keep in mind that our students are subsidized because universities do not pay taxes. It is not fair to subsidize the Japanese and other foreign students in this manner.

3. I believe that the lowering of the dollar value will help the US competitiveness in photovoltaics. It is beginning to be recognized by some of our international costumers that their currencies have become stronger with respect to the dollar. The net effect on our business however seems to be lagging the dollar yen ratio for instance. I don't really understand why.

4. I believe that the DOE's technology transfer efforts are not as effective as they could be. The problem is that the DOE does not have the resources necessary to take basic research results into the commercial sector by cost sharing with industry. We need to expand significantly the DOE's technology transfer budget.

5. Efficiency standards have not effected the high technology, i.e. photovoltaics part of the energy industry. This export related product produces electricity in applications not directly addressed by efficiency improvements.

6. DOE's photovoltaic program is the only program that continues to help industry to make progress with respect to the cost, efficiency, and reliability goals it set for itself in order to become a supplier of base load utility power. Accordingly, the program should be returned the mandate Congress provided in the Solar Photovoltaic Energy Research Development and Demonstration Act of 1978 (Public law 95-590). This legislation provided the authority and the funding basis in order to carry out two broad goals:

   - to facilitate production of electricity from photovoltaic systems cost-competitive with utility-generated electricity from conventional sources and
   - to resolve the technical, environmental, institutional, and legal issues involved in widespread adoption of photovoltaic power systems.

Roger G. Little

Date: 4/9/87

March 24 Renewable Hearing

QUESTIONS FOR ROGER LITTLE (PHOTOVOLTAICS)

Submitted by Senator Domenici

1. You mentioned that some foreign countries (Japan, Germany, France) provide photovoltaics to third-world countries in the form of foreign aid assistance. Does the U.S. have any similar policy? Is anyone in the industry encouraging this type of policy in the U.S.?

2. You implied that Japan "stole" our earlier U.S. R&D in photovoltaics. Do we have any similar access to their technology R&D? If not, how does Japan put up barriers? How can we better protect our own technology?

3. Is DOE's FY88 budget request consistent (in direction and size) with DOE's Five-Year Research Plan?

4. Do you feel DOE's photovoltaic R&D programs adequately address the "manufacturability" problem you identified in your testimony?

5. You stated that foreign competitors subsidize their photovoltaics industry. In what ways?

6. You state that foreign competitors have strong government support for R&D. In FY87, are there any countries that exceeded the U.S. in expenditures for photovoltaic R&D? If so, which countries? How much money?

7. You recommend increasing DOE support for utility-scale experiments. Hasn't DOE already provided a great deal of support here in the past? What were the results of such projects? If these projects are to be cost-shared, who should participate besides DOE?

8. Why haven't U.S. electronics firms assumed a larger role in photovoltaics commercialization, as Japanese firms have done?

9. Do you think our government could play a more active role in stimulating exports of photovoltaics? How so?

Response
To Questions Submitted by Senator Domenici

1. Some foreign countries (Japan, Germany, and France) provide photovoltaics to third-world countries in the form of foreign aid assistance. The U.S. does not have a similar policy. The industry has encouraged AID to initiate such a policy in regard to their aid to third world countries. This however has not yet been put into effect.

2. The Japanese have certainly taken advantage of early U.S. R&D in photovoltaics. They have done so by frequently attending our technical meetings and by placing students in our universities to participate in photovoltaics research and development. Although Japan does open its doors for cooperative technical meetings, it is difficult to gain more knowledge of their PV technology than what is published. In order to do so, we would have to place researchers in Japanese institutions. This is difficult with language barriers. The Japanese of course learn to speak English as we are an important market. One suggestion is to have foreign students be made to pay five times the tuition that American students pay to attend our universities.

3. The DOE's FY88 budget request is not consistent with DOE's Five-Year Research Plan. The DOE Five-Year Research Plan, developed with industry, government, and university input, calls for at least a $60 million per year budget level to achieve its goals.

4. The DOE photovoltaic R&D programs do not adequately address the manufacturability problem. The DOE programs are directed toward high risk basic research. Once basic research is done, it is left up to the industry to demonstrate manufacturability and commercialize the technology. After many years and great deal of resources are necessary to take laboratory results and to commercially viable products. Industry has been discouraged by the task.

5. Foreign competitors subsidize the photovoltaic industry through research and development budgets as well as system experiments programs. System experiments are now being fielded throughout Europe with the support of The Common Market governments. The U.S. DOE program dropped such experiments four years ago.

6. In 1987, the U.S. expenditures in photovoltaic R&D were not exceeded by any other countries. However, the Japanese budget and now the Italian budget is comparable to the U.S. budget.

7. It is necessary for utility scale experiments to be performed however, not at the substantial DOE investment level that has been conducted in the past. New utility scale experiments can be done at reduced power levels and still teach us how the basic technology fits utility requirements. These projects should be cost shared principally by utilities.

8. The U.S. electronics firms have not played a major role in photovoltaics commercialization as the Japanese firms have. This is principally due to the fact that the U.S. oil industry moved into photovoltaics during the energy crisis. They have, since their involvement, continued to invest heavily in the technology. However, as the energy crisis has passed and oil prices have dropped, they have begun to withdraw. Of the original oil companies involved in photovoltaics Chevron, Exxon, Sohio, Amoco, Mobil, Shell and Arco, only Arco and Amoco remain in the commercial sector of the market, while Mobil continues to do research.

9. The Government could play more active roll in the stimulating exports of photovoltaics principally through the use AID resources to procure photovoltaic systems for application to military installations throughout the world. In addition, the availability of low interest loans to countries that wish to procure photovoltaic products would also stimulate U.S. exports.

Roger G. Little

Date: 4/22/87

RESPONSES

To Questions Submitted by Senator Domenici

from

Robert W. Sherwin, Jr.

President

American Wind Energy Association

1. Q: If Congress were to take some action to help foster renewable energy programs, what action do you think would have the most beneficial effect on our industry: (a) provide more money for research and development, or (b) provide market and manufacturing incentives such as tax credits, accelerated depreciation, manpower training, etc.?

A: As between the two, (b) is unquestionably preferable. The private sector can operate much more efficiently than the public sector in making use of a given amount of funds. If tax incentives were to be restored for our industry in the future, however, they should be carefully structured to phase out over a period of years, rather than ending abruptly. A multi-year phaseout "holds industry's feet to the fire," while giving it time to adjust to a competitive marketplace.

Ideally, though, the federal R&D program should continue at some level. It provides a technical base and credibility for a new technology which is difficult for an emerging industry to achieve.

I would prefer to see a modest steady-state research program, perhaps at a level of $20-$25 million, coupled with a restoration of the energy investment tax credit for 6-10 years, beginning at 15% and being reduced by 2-3% per year.

2. Q: Why is it that foreign countries like Japan can so easily avail themselves of the renewable energy technology that has been developed in this country? Is the reverse situation true, that is, do we have easy access to technologies developed abroad? If not, what can we do to better protect our investments?

A: Foreign countries like Japan can readily avail themselves of American technology because it is a fundamental tenet of public policy in the U.S. to place information developed with public research dollars in the public domain. Additionally, America's society and business community is highly individualistic, and we have difficulty fashioning public/private consortia as the Japanese do to pool research efforts among a number of companies and government laboratories.

We do not have equally easy access to technologies developed abroad.

We can better protect our investments by improving the relationship between government research programs and industry. The American Wind Energy Association has chartered an R&D committee which meets twice a year with representatives of the Department of Energy and government laboratories. In addition, AWEA has strongly supported programs such as the Cooperative Field Test Program (CFTP), in which data for government research is developed using privately-operated wind turbines in the field. Increasing the informal communication and give-and-take among technical experts in the U.S. wind energy community is vital if we are to compete effectively in the global market.

3. Q. To what extent do you feel that the lowering of the dollar value will help U.S. competitiveness in renewables?

A. It will help. However, the U.S. wind industry has been so devastated by the loss of the tax incentive that it is poorly positioned to take advantage of the dollar's slide. We have gone from perhaps a dozen active manufacturers of windfarm-size turbines in 1983 to two today. More than a weak dollar will be required to fuel the industry's recovery.

4. Q. How effective do you think DOE's technology transfer efforts are? Is there room for improvement?

A. DOE's technology transfer efforts have been reasonably good. Its chief weakness in the wind energy area, up until the last few years, has been a preoccupation with large scale wind turbines to the detriment of a balanced program.

The department's technology transfer program is improving, and AWEA is working closely with it to ensure that that improvement continues.

5. Q. With respect to conservation efforts, do you think state and federal efficiency standards have been effective in promoting greater conservation? Is the imposition of efficiency standards as effective as federal support for R&D?

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The department's technology transfer program is improving, and AWEA is working closely with it to ensure that that improvement continues.

5. Q. With respect to conservation efforts, do you think state and federal efficiency standards have been effective in promoting greater conservation? Is the imposition of efficiency standards as effective as federal support for R&D?

A. This question is beyond the scope of my knowledge.

RESPONSES

To

Additional Questions from Senator Domenici

from

Robert W. Sherwin, Jr.

President

American Wind Energy Association

1. Q: You stated that we shouldn't be cutting wind energy research funds at a time when countries like Denmark and the Netherlands are increasing theirs. Can you provide the Committee with actual figures on R&D funds that Denmark and the Netherlands have committed to wind energy R&D over the last 5 years and compare that to U.S. commitments?

A. No, regrettably we cannot provide a dollar-for-dollar comparison. We can, however, provide the following facts:

1) U.S. R&D spending for wind energy has dropped by about 75% since the last Carter Administration research budget. The decline has been steady, with at least some funds being cut each year. The current Administration's representations to the contrary are mistaken. For example, Ms. Fitzpatrick said in response to a question that the Administration had submitted higher budget requests to Congress prior to Gramm-Rudman-Hollings. Yet President Reagan's first budget submission to Congress called for only $8 million to be spent on wind energy research in FY 1982. Coincidentally, that is the same total the Administration proposes to spend in FY 1988.

2) The Netherlands announced in mid-1986 a plan for subsidizing wind energy installations over five years with subsidies of $280/kilowatt installed in the first year, $220/kW in the second year, $160/kW in the third year, $100/kW in the fourth year, and $40/kW in the fifth year. The government said it hopes to reach 1,000 megawatts (MW) of installed capacity by the year 2000.

3) The Danish government has announced a program aimed at stimulating utilities to purchase 100 MW of wind turbines over the next five years, beginning this year.

4) It is our understanding that the Commission of the European Communities (CEC) will spend about 13 million European Currency Units (ecus)(about $13 million) during the current year for wind energy research projects. The

Commission's funding is leveraged by a practice of providing no more than 40% of the cost of a project, with the balance coming from other sources (national government, provincial government, utility, manufacturer, etc.). Thus a $13 million program by the CEC translates into some $30 million worth of projects. It should be noted also that these are, for the most part, demonstration projects aimed at helping to prove commercial feasibility of wind technology to governments, utilities and others.

While the commitments of individual national governments in Europe have been small compared to the U.S. federal program in the past, they are beginning to catch up, and they are not slacking off as we are. That is the reason our Association recommends that wind energy funding at least be held level here in the U.S., despite the overall budget constraints the Congress faces.

2. Q: You recommend that DOE support utility-sized demonstration projects in order to promote utility acceptance. Has DOE cost-shared any of these sized projects to date? Should they be cost-shared? With whom?

A: I have scrutinized our written testimony and reviewed my oral testimony to the best of my recollection, and I do not believe this recommendation came from AWEA. The few utility-scale wind projects DOE has initiated were begun in the days of relatively large budgets, and their continued appetite for dollars has been very destructive as the wind program has shrunk.

We would prefer to see government purchases of wind equipment in moderate amounts (i.e., to avoid a "boom and bust" situation), and government export assistance to the remnant of the wind energy industry that still exists and is trying to make its way in an increasingly difficult marketplace. We would greatly like to see funding for the activities of the U.S. Committee on Renewable Energy Commerce and Trade (CORECT) increased, so that it can provide more effective assistance to U.S. companies competing for overseas business. And we would like to see federal support for demonstration projects in selected target countries such as Greece, which has an excellent wind resource and no domestic capability to manufacture medium to large scale wind turbines.

3. Q: Could you elaborate on the program areas in which you feel DOE should reduce funding levels? Why do you think these areas are over-funded? Why do you think DOE continues to provide the support level it does?

A. In general, we favor increasing funds for all energy research. The potential energy and national security problems this nation faces over the next decade if present trends continue unchecked are frightening, and the Congress should economize somewhere else.

However, given the political reality of very scarce research dollars, AWEA would single out nuclear fission and fusion as areas of relatively low priority at the present time.

With respect to fission:

1. The nuclear industry has serious problems which are not going to be wished away. After Three Mile Island, WPPSS, and Chernobyl, it is obvious that this industry is not going to be expanding any time soon, and that its public support is very low.

2. The nuclear industry is far larger than our industry, and its technology is fairly well-understood, having received enormous federal subsidies over the years. What, then, is the justification for continuing to fund fission research at a level several times the amount committed to all of the renewable energy technologies added together?

3. The costs of large central generating plants, particularly when energy demand is fluctuating as it is today, cannot be supported. There are single fission plants in existence today, some operating and some abandoned, for which the cost overruns alone would be sufficient to pay for thousands of megawatts of wind capacity.

With respect to fusion:

1. Fusion plants are almost certain to be much more complex and expensive to build and operate than fission plants. It seems likely, therefore, that they will be vulnerable to the same problems of cost overruns and shoddy and unsafe operation.

2. Fusion plants also produce radioactive waste products which pose environmental problems of uncertain duration and cost.

We believe these areas are over-funded because of a preoccupation with the fantasy of "economies of scale". Such economies apply only when there is steady increase in demand and a stable market, as General Motors is learning today. WPPSS, Marble Hill, and other multi-billion-dollar abandoned nuclear projects stand as testimony to the fact that the electric utility business cannot go on in the future as it has in the past. Technologies which offer modularity, flexibility, and swift construction times must be considered superior to those which do not.

Fusion, of course, also promises power from an unlimited, cheap fuel supply. But so does renewable energy, and without the enormous technological problems posed by fusion.

If areas must be cut, then, these are our recommendations. They are currently very well funded by comparison with renewable energy, and with increasingly weaker justification.

LUZ INTERNATIONAL LIMITED

LUZ

May 10, 1987

The Honorable Wyche Fowler, Jr.
Vice Chairman, Subcommittee on
Energy Research and Development
United States Senate
Washington, D.C. 20510

Dear Senator Fowler:

Thank you for the opportunity to appear before the Senate Energy Committee last month during your hearings on alternative energy resources. I applaud your attention to this important policy area and appreciate your particular concern for the continued encouragement of solar thermal energy.

It is a pleasure to respond to the questions submitted for the record by Senator Domenici. My responses to those questions are attached.

As you continue to develop your legislative proposals in the area of alternative energy, we at LUZ remain available to be of assistance in any way that would be helpful to you. As our industry matures, we remain grateful for the past and present encouragement that you have personally given us.

With all best wishes,

Sincerely,

Patrick Francois

Attachment

PF/ce

MAY 11 1987

March 30, 1987

Questions Submitted by Senator Domenici

1. If Congress were to take some action to help foster renewable energy programs, what action do you think would have the most beneficial effect on our industry: (a) provide more money for research and development, or (b) provide market and manufacturing incentives such as tax credits, accelerated depreciation, manpower training, etc.?

(1) As alternative energy technologies mature, the need for research and development and tax subsidies is diminishing, but the need for market incentives remains very strong.

The PURPA program together with special tax credits fostered the deployment of numerous technologies. The challenge today is for companies that have grown in this protected environment to flourish. The need for PURPA market incentives remains crucial, particularly as the tax credits are phased out by the end of 1988.

In the case of our company, and any other company that seeks to make the transition from the experimental stage to the fully competitive stage of development, the need for market incentives is coupled with a need for freedom to compete, particularly in capital markets. The need for capital is fundamental in any business, but especially in ours where alternative energy technologies by their basic design substitute capital at the front end for fossil fuel consumption over the life of a conventional project. Policies that recognize our need to benefit from the market incentives of PURPA and to compete without the burden of excessive regulation are key to our continued growth.

2. Why is it that foreign countries like Japan can so easily avail themselves of the renewable energy technology that has been developed in this country? Is the reverse situation true, that is, do we have easy access to technologies developed abroad? If not, what can we do to better protect our investments?

(2) In the case of solar thermal technology, the United States has proven to be the most adaptable market for the penetration of a technology developed in part in the U.S. and in part overseas. The LUZ technology is the combined product of technology developed in the U.S. and Israel, and specialized manufacturing processes developed in other foreign countries including Germany and Italy as well as the U.S. and Israel. Although other regions offer the right climatic conditions, the market incentives of the PURPA program and the price incentives of the tax credits, combined with the right climate, created a unique environment in the U.S. for the development of solar thermal technology. While there are several regions of the

world where the technology should be economic and could foster energy independence, U.S. energy policies combined with flexible financial markets that allow for risk-taking and experimentation have been the key to our success.

3. To what extent do you feel that the lowering of the dollar value will help U.S. competitiveness in renewables?

(3) The fluctuating value of the dollar creates a certain amount of uncertainty in all business transactions, but is not likely to alter tremendously the economic horizon for solar thermal technology, or other alternative energy technologies. Since the price of oil tracks the price of the dollar, the absolute value of power produced from conventional fossil fuel plants, which is the benchmark for our ability to compete, will remain unchanged by modest fluctuations in the exchange rate. In the area of export markets, there should be some boost from a lower valued dollar. We are currently exploring potential projects in several countries, including Israel, India and Australia. To the extent that a declining dollar makes U.S. components and services less expensive, there should be additional international demand for our technology.

4. How effective do you think DOE's technology transfer efforts are? Is there room for improvement?

(4) In the case of solar thermal power production, technology transfer has worked very well. In fact, it is a model of cooperation and adaptation. As I noted in my testimony, our technology is a blend of research sponsored by the Department of Energy and research conducted by a consortium of utilities. Moreover, because the research was available to scientists and engineers in the U.S. and overseas, adaptations pioneered in Israel could be successfully deployed in the California desert.

In general, the technology transfer process is greatly enhanced by early and ongoing consultation with industry to match research and development with business plans and needs. Looking to the future, the remaining area where research and development would be helpful is heat storage. The lack of an efficient and reliable heat storage system limits our technology to use at the times of day when there is sunlight. With storage capacity, system reliability could be assured with even less reliance on fossil fuels for power when solar power is otherwise unavailable.

5. With respect to conservation efforts, do you think state and federal efficiency standards have been effective in promoting greater conservation? Is the imposition of efficiency standards as effective as federal support for R&D?

(5) No specific comment.

April 1987

QUESTIONS FOR PATRICK FRANCOIS (SOLAR THERMAL ENERGY)

Submitted by Senator Domenici

1. You say that your company will remain competitive despite a phasing out of tax credits. But you already have your commercial enterprise on solid ground. What about other companies and other technologies that have not advanced to the commercial phase yet? Will these companies be able to survive, and will the newer technologies be commercialized in the absence of tax credits or some other form of federal market incentives?

(1) Our company was certainly helped by the tax credits and it is probably fair to say that without those special tax credits our early projects would not have been possible. We have been operating in an environment of depressed oil prices which makes the economics of any alternative energy technology difficult at this time. Competing with today's low oil prices distorts the long term value of alternative energy projects since these technologies substitute capital costs at the front end for fossil fuel costs over the life of the project. Tax credits have been key to showing the necessary after tax return on investment to attract capital to new and relatively high risk projects at a time when energy prices have been low.

If oil prices climb substantially over the current level, the economics of investing in alternative energy projects will change dramatically. PURPA created a market for us to sell our power in, and that market has been and continues to be essential to our development. When you ask about other market incentives, you are really asking about price. If the price of oil and the price paid for power is high, tax incentives are less important. Although I cannot directly address the financial outlook for other companies, in the current climate of depressed energy prices, commercializing an experimental technology without tax credits would be quite difficult and extension of the tax credits would clearly improve the prospects for other new technologies. Even to sustain a successful commercial scale operation like ours without tax credits will require substantial cost reductions and efficiencies.

2. You have plans to develop a U.S. export market for your company. Have you looked into the government's policies with respect to technology export? Do you see any barriers? How do our export policies compare with other countries'? How can we improve our position with respect to the world markets?

(2) Our attempts to export LUZ technology have been limited to date, but our experience suggests that there is both a need for

and interest in our technology overseas. The biggest problem we face is finding financing for projects, particularly in third world countries. The PURPA program is unique in the way it created a U.S. market for alternative energy in conjunction with regulatory exemptions and tax credits that eliminated many barriers that otherwise would have existed to financing our U.S. projects. Any effort by the U.S. either as part of its foreign aid and trade policies or in other bi-lateral relations to encourage the development of financing mechanisms for projects like ours would be tremendously helpful. If the market is available overseas, and financing is available, we believe our technology and services would be attractive.

3. Did LUZ derive any of its present technological know-how from government-sponsored research programs under DOE? If so, how smooth was the technology transfer process? Do you have any suggestions for improvements?

(3) In our experience technology transfer has worked very well. As I mentioned in my testimony, in the 1970's and early 1980's the Department of Energy funded research in basic solar technologies. Our technology, the parabolic trough, was developed to use solar thermal energy for industrial heat. Another technology, central receiver technology, was developed for electric generation with Solar One, supported by Southern California Edison and other utilities. LUZ technology is based

on the results of both the DOE funded solar research on the parabolic trough and the Solar One demonstration of the proper integration of solar generated steam with the power block needed to generate electricity. By learning from these two research and development efforts, we were able to refine a technology for commercial use. This research provided the basic building blocks for our commercial demonstration of solar thermal technology.

In general, the key to effective technology transfer is coordination between industry and research and development projects. Early consultation to target necessary areas for R&D and ongoing consultation to integrate the results is essential to smooth technology transfer.

Follow-up Questions to

Dr. Hubbard
Solar Energy Research Institute, Colorado

Request from Senator Fowler: "It would be very helpful, Dr. Hubbard, if you would submit in the next few days for the record your ideas on what a basic multiyear authorization might be to avoid erratic funding."

Reply: Each year when we support DOE in the budget and planning process, we jointly examine a number of program options and alternatives. As is the case in any such process, within the overall fiscal and budget restraints, we are unable to accommodate many of the promising research initiatives that our scientists believe have merit and could make useful future contributions to the nation's energy supply. The current budget year is no exception. In each of the program areas for which SERI is responsible, there are research activities where additional funding could be productively applied. Multiyear authorizations would permit multiyear planning which could accommodate these initiatives as the program develops.

Since I first came to SERI as Acting Director in 1981, I have felt and so indicated to DOE management, that stability and continuity were the most essential factors in assuring a successful solar research program. If a multiyear program was authorized, I believe it should contain the following elements:

1. It would harness the strongest option available to the United States (i.e., our scientific and technical resources) in seeking to maintain domestic energy security. This implies an integrated, multiyear strategy with appropriate attention devoted to each of the major programs utilizing domestic resources—coal, nuclear, and renewables.
2. It would account for the long-term nature of the energy issue and would provide for a stable research program with consistent goals, recognizing that this is the most cost-effective way to do research and develop technology. The DOE Office of Conservation and Renewable Energy, supported by SERI, has developed multiyear program plans for most of the renewable technologies, projecting research plans out five years. Under the present complex annual budgeting process, it is not possible to confidently predict funding levels, and this makes it difficult to carry out the plans in a systematic way.
3. It would allow for flexibility. That is, if developments are such that some technologies progress better than expected or have become better avenues for the country to follow, then the programs will have flexibility to follow those avenues.
4. It would promote improved industry, government, and academia interaction to keep the program focused on the most cost-effective paths.
5. It would promote the continued building and maintaining of a large scientific and technological knowledge base that is easily accessible to industry and the public.
6. It would promote enhanced means by which federal government research and development results can be transferred to industry and to state and local governments.
7. It would continue to encourage effective cooperation and joint efforts between government and industry. In so doing, it would foster the development of an industry that supplies and uses advanced conversion technologies which have proven technical and economic feasibility.

Questions from Senator Domenici:

Question 1: If Congress were to take some action to foster renewable energy programs, what action do you think would have the most beneficial effect on our industry: (a) provide more money for research and development, or (b) provide market and manufacturing incentives such as tax credits, accelerated depreciation, manpower training, etc.?

Reply: I think that both are important to the welfare of our fledgling industry. And, the relative emphasis between R&D funding and providing other incentives and "disincentives" to industry depends upon the urgency with which the public and elected officials perceive the problem and the energy issue.

Having said this, however, I must reiterate my view that our greatest resource, and that which therefore will benefit industry most, is maintaining the competitive edge we have in science and technology. To keep and augment this edge, we must continue to expand our knowledge base and we must develop and husband the industrial capability to use that knowledge base as changing and unpredictable circumstances dictate.

As a professional R&D manager, I believe the best way to have our competitive edge is through research and development. This is not a conclusion I came to alone, however. Recent testimony to the Congress by both DOE and the solar industry generally supports this view.

Question 2: Why is it that foreign countries like Japan can so easily avail themselves of the renewable energy technology that has been developed in this country? Is the reverse situation true, that is, do we have easy access to technologies abroad? If not, what can we do to better protect our investments?

Reply: When discussing our position relative to the Japanese in renewable energy technology we are not talking about the broad topic of renewable technologies, we are primarily talking about the specific technology of photovoltaics (PV).

I believe and my staff believe, that while the Japanese have a very impressive research effort in PV, the U.S. effort is slightly ahead of the Japanese. There is significant exchange and sharing of basic scientific ideas between the U.S. and Japanese research communities, which appears to work to the advantage of both.

It is commonly said that Japan is ahead of the U.S. in commercializing PV. The statement needs to be looked at closely. The Japanese have taken advantage of their well-developed expertise in consumer products and have successfully applied PV to that market. The U.S., however, is the leader in the production and marketing of PV modules for large scale electric power generation.

Having said this, we must note that the Japanese have a record of forming strong partnerships between government and industry and they are willing to invest for the long haul. If the U.S. does not also maintain a strong, long-term government/industry cooperative effort in PV, the Japanese could dominate the major PV power markets that are just beginning to emerge.

Question 3: To what extent do you feel that the lowering of the dollar value will help U.S. competitiveness in renewables?

Reply: Frankly, this question lies outside my personal area of competence. However, let me venture a comment. Reduction of the value of the dollar against the Japanese yen and the major currencies of Western Europe will be of some help to U.S. competitiveness in renewables. Government activities like CORECT (Committee on Renewable Energy Commerce and Trade) coupled with industry efforts such as the Renewable Energy Export Trade Council will also help. However, the impact of lower dollar value will be limited because the dollar has not dropped versus the currencies of the Third World and countries of the Pacific Rim.

Question 4: How effective do you think DOE's technology transfer efforts are? Is there room for improvement?

Reply: SERI has worked closely with DOE's Office of Conservation and Renewable Energy to carry out the Department's technology transfer program. On the whole the program is effective and is continuing to improve as interaction with the private sector gets stronger.

Technology transfer is a complex and difficult process. This is true, as I know from experience, even in the relatively straightforward case of a private company transferring results from its research laboratory to production and commercial use. It is even more difficult when the transfer is across the cultural and organizational gap between government programs and private industry.

Technology transfer is not a spontaneous process. It requires continuing effort. To be successful a variety of techniques must be used—publication of the results, licensing of patent rights, conferences for the exchange of information and consultation between government and industry, and the conceptualization of programs and the definition of research goals. The exchange of technical personnel between industry and government laboratories is important and effective. So are subcontracts to industry and cost-sharing agreements in which industry picks up the laboratory technology and develops the potential for commercialization. All of these things are being done, but they can be done better. SERI and DOE are working on ways to improve the process.

Question 5: With respect to conservation efforts, do you think that state and federal efficiency standards have been effective in promoting greater conservation? Is the imposition of efficiency standards as effective as federal support for R&D?

Reply: SERI has had very little involvement in the area of state and federal efficiency standards and, therefore, I am not in a position to comment on their effectiveness. Certainly the nation has saved many quads of energy through conservation, although it is difficult to say how much reduction in energy use is driven by the economy and how much is driven by standards or regulations.

In regard to the second part of the question, standards and R&D are germane to different, although related, issues. Standards tend to affect evolving technologies and R&D addresses the creation and development of new technologies.

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Congress of the United States
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JOHN H. GIBBONS
DIRECTOR

April 7, 1987

The Honorable Wyche Fowler, Jr.
Vice Chairman
Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

Thank you for your follow-up questions regarding OTA's testimony before the Subcommittee on Energy Research and Development on March 26, 1987. Enclosed is our response to those questions. Some time next week I will also forward a brief staff paper in response to your request in the hearing for additional information on options for accelerating renewable energy technology research and development. This paper summarizes and updates a number of options identified in our assessment New Electric Power Technologies: Problems and Prospects for the 1990's. If you, any Member of the Committee, or the Committee staff have any additional questions or would like elaboration on our response we would be pleased to provide further information.

Thank you again for the opportunity to testify on this important issue before your Committee.

Sincerely,

Peter D. Blair
Director
Energy and Materials Program

PDB/apl

P. Blair Senate Energy Testimony 3/26/87: Follow-Up Questions

Questions Submitted by Senator Domenici

1. **If Congress were to take some action to help foster renewable energy programs, what action do you think would have the most beneficial effect on our industry: (a) provide more money for research and development, or (b) provide market and manufacturing incentives such as tax credits, accelerated depreciation, manpower training, etc.?**

The answer to this question varies by type of renewable technology. Some technologies that are commercial or near commercial, e.g., photovoltaics or wind turbines, would benefit most from investment incentives. Others that require considerably more development before commercial applications can be realistically considered, such as solar thermal power or advanced geothermal power systems, would benefit more by increased research, development, and demonstration support, both direct support and cooperative research and development programs.

2. **Why is it that foreign countries like Japan can so easily avail themselves of the renewable energy technology that has been developed in this country? Is the reverse situation true, that is, do we have easy access to technologies developed abroad? If not, what can we do to better protect our investments?**

This problem is not unique to renewable energy technology. Results from basic research and development (R&D) in this country are distributed widely throughout the world. Part of this trend is due to our more open culture about basic R&D and part is due to the fact that our results are disseminated in the English language, which is a second language to virtually all of the industrialized world. The reverse is only partly true. Japan, for example, maby be more guarded in disseminating basic R&D results and U.S. interests seldom avail themselves of it when results are disseminated, particularly if they are not published in English.

Another aspect of this problem, at least as far as applied R&D is concerned, is that many foreign renewable technology vendors are heavily supported by their governments. This coupled with the current lack of U.S. demand for some renewable power technologies in grid connected power generation applications raises the concern over the continued commitment of U.S. firms to developing these technologies. The renewable power technologies that appear to show the most promise for substantial deployment in the 1990's are those that currently serve or have the opportunity to serve markets other than the domestic utility grid. Foreign vendors are aggresively pursuing these markets with the help of their governments, more so than U.S. vendors. Such markets are especially important while demand for new electric generating capacity continues to be low and while cost and performance of these technologies are uncertain in grid-connected applications. For some of these technologies these markets are also foreign, so efforts on the part of the U.S. government to assist in establishing access to markets for new generating technology equipment in foreign countries could be very important to the near time viability of U.S. firms developing these technologies.

P. Blair Senate Energy Testimony 3/26/87: Follow-Up Questions

3. To what extent do you feel that the lowering of the dollar value will help U.S. competitiveness in renewables?

Lowering of the dollar value will help U.S. companies be competitive in foreign markets for renewables where competitive technology exists. The principal problem in the case of renewable energy technology, however, is that in many instances current U.S. technology is lagging behind that of foreign vendors in terms of cost and performance. Hence, while a lower dollar value would help, it may not be sufficient for improving U.S. competitiveness in renewables.

4. How effective do you think DOE's technology transfer efforts are? Is there room for improvement?

With the possible exception of the Clean Coal Technology Reserve, DOE's technology transfer program is aimed at basic science and engineering. In renewables much of this effort is coordinated through institutions like the Solar Energy Research Institute and the national laboratories, and generally has been very effective. The shift away from federal involvement in proof-of-concept and early commercial demonstrations, however, has slowed commercial development of renewables considerably. In the case electric power generation applications in particular, completion of a commercial demonstration program is a critical milestone in both utility and non-utility power producer acceptance of new technology. A cooperative industry and government research and development partnership has proven to be a key ingredient in many successful demonstration programs.

P. Blair Senate Energy Testimony 3/26/87: Follow-Up Questions

5. With respect to conservation efforts, do you think state and federal efficiency standards have been effective in promoting greater conservation? Is the imposition of efficiency standards as effective as federal support for R&D?

Building and appliance efficiency standards have been effective in promoting energy conservation. The most difficult impediment facing increased market penetration of energy efficient appliances is the often high first cost of such appliances, even though their life cycle costs are usually very competitive. In terms of promoting increased conservation, efficiency standards mitigate some of the first cost bias by eliminating very low first cost alternatives that are generally very energy inefficient. In addition, first costs of energy-efficient appliances might be reduced with Federal standards since they would pre-empt widely differing State standards that complicate and, hence, increase the cost of appliance manufacturers' manufacturing and distribution mechanisms.

Efficiency standards and R&D support address entirely different issues. R&D addresses developing technologies while efficiency standards address, for the most part, commercially available technologies.

* * *

Renewable
Energy
Institute

May 19, 1987

The Hon. Wyche Fowler, Jr.
Vice Chairman
Subcommittee on Energy Research & Development
Committee on Energy and Natural Resources
U.S. Senate
Washington, D.C. 20510

Dear Senator Fowler:

I enclose a set of responses to Senator Domenici's questions, following your hearings on March 26. The questions deserved a thoughtful response, and thus required more time than we had anticipated.

I hope that these will be useful to you, and would add only that if we can be of any further assistance to you, you need only ask.

Sincerely,
Frank Potter
Frank M. Potter, Jr.
President

1001 Connecticut Avenue, N.W. Suite 719
Washington, D.C. 20036
202/857-1660

RESPONSE TO SENATOR DOMENICI'S
QUESTIONS AT MARCH 24th AND MARCH 26th HEARINGS

1) *If Congress were to take some action to help foster renewable energy programs, what action do you think would have the most beneficial effect on our industry: (a) provide more money for research and development, or (b) provide market and manufacturing incentives such as tax credits, accelerated depreciation, manpower training, etc.?*

Both incentives can be important, but they will benefit different technologies in different ways, depending on how advanced the particular renewable energy technology is. For this reason, renewable energy policies should be tailored with each technology's commercial status in mind. Those technologies in a research and development (R&D) phase should be eligible for cooperative R&D ventures with industry but with the latter retaining some proprietary rights. For those technologies in advanced R&D but not yet commercial, demonstration and system experiments are vitally needed. These projects could be cost-shared by industry, end-users: e.g., utilities and state and federal governments. For technologies that are commercial but not competitive, tax incentives should be restored and/or retained to offset the high initial capital costs.

Besides increased research and development allocations and the continuation of tax incentives, several other options for government action would be helpful to the U.S. renewable energy industry. These include:

- government procurement of renewable energy technologies that are economically viable, such as remote photovoltaics and domestic solar hot water systems, for use at publicly-owned facilities;

- rethinking the research and development credits reduced by the Tax Reform Act of 1986. According to a recent General Accounting Office study, the severe decline in the DOE renewables budget has not been made up by private research and development expenditures by the U.S. renewables industry, with the exception of photovoltaics. This contrasts dramatically with our international competitors, who are devoting increasing amounts of public and private resources to renewable research and development programs;

- stimulating the enormous export potential of renewables. With the exception of the Committee on Renewable Energy Commerce and Trade (CORECT), the U.S. government and, to a certain extent, the U.S. renewable energy industry, have largely neglected this potential market;

- Finally, the U.S. Congress can make an important statement for renewables by reversing the precipitous decline in federal renewable research and development expenditures. A recent CRS study showed that overall U.S. DOE renewable funding has declined by 87% since FY1981, including the President's FY1988 request. My testimony provides more specific numbers on this question.

2) *Why is it that foreign countries like Japan can so easily avail themselves of the renewable energy technology that has been developed in this country? Is the reverse situation true,*

that is, do we have easy access to technologies developed abroad? If not, what can we do to better protect our investments?

The assumption that the U.S. has exclusively developed renewable energy technologies is generally not true. Countries like Great Britain, Japan, and Australia have conducted extensive R&D and market development of their own and have generally made this information available to the U.S. It might be more appropriate to ask how the U.S. can regain market competitiveness or even dominance in specific renewable energy technologies. The U.S. lost its market leadership position in wind and photovoltaics in 1985 and 1986, and inroads are currently being made on U.S. competitiveness in other renewable technologies such as geothermal and solar heating and cooling. In addition, the poor health of the U.S. renewable energy industry has forced many U.S. companies to sell their technology overseas or even to distribute foreign products in the U.S. Is this trend reversible?

In part, the answer may lie in the responses to Question 1. Leveraging government and private resources to demonstrate, on a commercial level, renewable energy technologies, restoring and/or renewing renewable energy tax incentives, and stimulating government purchases of renewable energy systems will do much to overcome private sector and end-user hesitation about renewable energy and stimulate markets for U.S. renewable energy products.

In addition, current DOE R&D practices for renewables do little to stimulate market development of renewable energy systems. Currently, the Department practices a policy of long-term, high-risk, and potentially high-payoff basic R&D. It opposes governmentally-funded commercial demonstration projects, preferring to leave commercialization initiatives to the private sector. Basic R&D is certainly essential to the development of any technology, but it cannot be conducted in a context in which market development is ignored. In Japan, for example, research and development objectives are determined in a consensus process involving industry, government, and academia. Furthermore, Japan's government is involved in every step of a technology's development, from basic research to commercial development to market deployment. The U.S. could certainly learn useful things about R&D approaches from international competitors like Japan.

3) *To what extent do you feel that the lowering of the dollar value will help U.S. competitiveness in renewables?*

The decline in the value of the dollar will certainly help, but its effects are limited and should not encourage indifference regarding our competitiveness in renewables or the state of the U.S. renewables industry. The problems facing the U.S. renewable energy industry—aggressive international competition, declining domestic markets, an indifferent Administration, lack of access to institutional capital—are deeply rooted and will generally not be positively or negatively affected by falls and rises in the dollar's value.

4) *How effective do you think DOE's technology transfer efforts are? Is there room for improvement?*

There have been some successes in DOE's technology transfer program, such as stressed membrane heliostats for solar thermal systems, but the program could be substantially improved. In general, DOE tends to restrict itself to publication of the results; it has not aggressively followed these up to ensure that the results are integrated into the marketplace or in decisionmaking among utilities, other governments, or among other end-users. Moreover, these programs tend to be the first to get cut at the national laboratory and the last to be funded.

5) *With respect to conservation efforts, do you think state and federal efficiency standards have been effective in promoting greater conservation? Is the imposition of efficiency standards as effective as federal support for R&D?*

State and federal efficiency standards have been successful in some areas, most notably automobile fuel efficiency. Building efficiency regulations have been less effective, for a number of reasons, not all of which can be traced to bureaucratic ineptness. Automobile and appliance efficiencies should be further encouraged.

As to the effectiveness of efficiency standards as opposed to federal R&D programs, both are necessary—neither should be sacrificed for the other.

American Council for an
Energy-Efficient Economy

1001 CONNECTICUT AVE., N.W. SUITE 535 WASHINGTON, DC 20036 (202) 429-8873

April 7, 1987

Senator Wyche Fowler, Jr.
Vice Chairman, Subcommittee on
Energy Research and Development
Committee on Energy and Natural Resources
312 Hart Senate Office Building
U.S. Senate
Washington, D.C. 20510

Dear Senator Fowler:

Below are answers to Senator Domenici's questions sent to me last week. Most of the questions refer to renewable energy technology, an area in which our organization does not work. However, since most of these questions are also applicable to energy conservation technology, I've taken the liberty of answering questions relevant to conservation as if they addressed conservation.

2. Why can foreign countries, like Japan, easily avail themselves of U.S. conservation technology, and do we have easy access to their conservation technology?

Although I can't answer this question for all foreign countries, I can answer it for Japan. But it's reasonable to assume that my answer for Japan describes the situation with at least some other foreign countries.

Japan has relatively easy access to technology developed in this country because it makes a tremendous effort to monitor technological development in the U.S. Its researchers attend U.S. seminars and conferences, its engineers enroll in U.S. universities and work with U.S. research institutions. In contrast, U.S. companies and researchers expend relatively little effort to monitor technological development in Japan.

Part of our problem in accessing Japanese technology is due to the language barrier. Few Americans can read or speak Japanese, and relatively little of the valuable technological information made publicly available in Japan is translated into English. On the other hand, virtually all educated Japanese can read English and many of them can speak English. Thus, the difference in language presents less of a barrier to Japanese researchers than to their American counterparts.

We know of no evidence that Japan is any more protective or secretive with technological information than the U.S. The way to reduce the disparity in technological access between the countries is for the U.S. to increase its efforts to learn about technologies being developed in Japan.

The alternative budget for energy conservation I presented at the hearing contains a recommendation that addresses this issue. The alternative budget recommends that an international energy conservation research monitoring program be established within the Multi-Sector Program of DOE's Office of Conservation and Renewables. As proposed, the program would monitor foreign technological development, collect information, translate foreign materials into English, and make information available to U.S. researchers. The budget proposes a modest $500,000 level of funding.

3. Will lowering the value of the dollar help U.S. competitiveness in conservation products?

A lower dollar will undoubtedly make U.S. products more competitive abroad, but the main problem with many U.S. conservation products is not cost. It's technology. Because many of our foreign competitors have a history of higher energy prices and thus more interest in conservation technology, and because many of their governments have a stronger commitment to energy conservation, foreign competitors often have superior conservation technology in the products they ship to the U.S. To be more competitive with these products, U.S. manufacturers must have better technology. Federally-supported conservation R&D has a proven track record of delivering advanced, valuable technology to U.S. companies that makes them more competitive.

4. How effective are DOE's technology transfer programs?

On the whole, DOE's conservation R&D technology transfer has been very successful. DOE has worked very closely with many companies through every stage of research and development, from long-range research plan development to financial support of projects. As a result, companies are well informed of DOE's activities and ready to put newly-developed DOE technologies to use when research projects are completed.

Some excellent examples of this close DOE/industry cooperation deserve mention. In a cost-shared arrangement, GTE worked closely with DOE to develop a high-temperature, cross-flow, ceramic recuperator, which recovers waste heat from hot, fouling industrial waste gasses. Over 700 of the recuperators are now in use and are estimated to be saving 3 trillion Btu of energy per year. DOE also worked closely with a number of companies to develop a low-emissivity coating for window glass, which transmits visible light but reflects heat. Most major glass manufacturers are now making "low-e" glass. The glass is expected to control 50% of the window glass market by 2000, and annual energy savings attributable to the new glass is expected to exceed $100 million per year by 1995.

Despite DOE's overall success in transferring conservation technology to private industry, DOE has experienced difficulty in getting some of its building envelope research results adopted by the building construction industry, which consists of thousands of small companies. The industry is much more difficult to communicate with than industries that are dominated by fewer medium and large companies. Cooperation from the industry's national association -- National Association of Home Builders -- is therefore very important. Unfortunately though, DOE has not been able to work as closely as desired with NAHB because NAHB had been vehemently opposed to DOE's development of the Congressionally-mandated Building Energy Performance Standards, a major DOE research project that permeated many of DOE's buildings research programs. However, the project was transformed into a voluntary standards program a few years ago. NAHB is consequently less hesitant to become involved in DOE research projects. DOE's ability to transfer technology to the buildings construction industry is thus improving.

In conclusion, I see no major problems with DOE's technology transfer efforts. DOE understands that industry involvement in its programs is the best way to assure successful technology transfer. The problems that developed in the building construction industry should eventually dissolve.

5. Have federal and state energy efficiency standards effectively promoted energy conservation? Are they as effective as federal support for R&D?

There is no doubt that state and federal standards have been highly effective in promoting energy conservation. The most important conservation standards ever initiated by Congress are the Corporate Average Fuel Economy Standards. These standards have helped usher in a new generation of automobiles that are almost twice as efficient as new cars sold in 1973. Were it not for the increase in automobile fuel economy between 1978 and 1985, the U.S. would now be consuming an additional 1.5 million barrels of imported oil per day at a cost of almost $10 billion per year. (See testimony of Marc Ledbetter before the House Subcommittee on Energy Conservation and Power, Committee on Energy and Commerce, September 1985.)

Of course this increase in fuel efficiency was not caused by standards alone. Higher gasoline prices were also responsible for the increase. But in the absense of standards, improvement in fuel efficiency would have lagged, especially in the years between 1973 and 1979 when real gasoline prices fell.

The California appliance efficiency standards are another good example of effective standards. The California Energy Commission now estimates that the standards have reduced peak power needs by 1750 megawatts (a large nuclear power plant can produce about 1000 megawatts) and have saved consumers $600 million.

A recent analysis of the newly-passed national appliance efficiency standards estimates these standards will save consumers $28 billion over the life of affected-appliances, after deducting for the increased purchase cost of more efficient appliances. These savings are over and above efficiency increases caused by market forces. (See testimony of Howard Geller before the House Subcommittee on Energy and Commerce, Committee on Energy and Commerce, September 1986.)

Though efficiency standards have effectively promoted conservation, it is hard to say they are more effective than federal support of conservation R&D. Like the standards cited above, federally-supported R&D programs can show enormous energy savings. Federal involvement in the development of solid state ballasts for fluorescent lighting is expected to save the U.S. $25 billion in the five years by which the federal government advanced commercialization of the ballasts. Similarly, federal involvment in the development of the low-e windows mentioned above is expected to save the U.S. $13 billion over five years. In fact, just seven successful federally-supported R&D projects are expected to save the U.S. $68 billion, yielding a return on federal investment to the taxpayer of 4400 to 1. (See "Federal R&D on Energy Efficiency, a $50 Billion Contribution to the U.S. Economy," American Council for an Energy-Efficient Economy, February 20, 1986. Enclosed)

Conservation R&D complements efficiency standards well. Standards can be set at efficiency levels that are above what the market would achieve, but nonetheless, cost-effective to consumers and the economy. Federally-supported R&D can then provide companies with research and technology that will help them meet the standards.

Thank you again for the opportunity to testify. I hope you have found our information helpful.

Sincerely,
Marc Ledbetter
Marc Ledbetter

P.S. I just learned that Dr. Art Rosenfeld, one of the hearing panelists, received the above set of questions today, April 7, 1987. (Perhaps we should be discussing how to make our Postal Service more efficient.) Given that he can't possibly respond to the questions before deadline, and that we have very similar views on the questions, he asked that my above responses also serve as his.

FEDERAL R&D ON ENERGY EFFICIENCY
A $50 BILLION CONTRIBUTION TO THE U.S. ECONOMY

A White Paper on the Consequences of Proposed FY 1987 Budget Cuts

by:

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February 20, 1986

PART A: BENEFITS OF THE FEDERAL R&D PROGRAM

Executive Summary

The Administration's 1987 budget proposes to cut federal energy conservation research and development by 60 %, on top of previous budget reductions totaling nearly 50 % since 1980. The U.S. already spends far less on conservation R&D per unit of energy consumption than most industrialized countries. Further cuts, if implemented, would weaken our national security, cost U.S. consumers billions of dollars in excess energy costs each year--even with lower oil prices--and run counter to the Administration's stated goal of reducing the national deficit. Part A of this White Paper explains the compelling economic and security reasons for maintaining federal energy conservation R&D at least at current funding levels:

- **There is a broad national consensus on the need to increase energy productivity in all sectors.** Improved energy efficiency will reduce the multi-billion dollar annual drain on our economy, buy us the time to diversify our long-term energy options, and mitigate a number of our most pressing environmental problems.
- **We have already made huge gains** in reducing energy use per dollar of GNP. If today's economy still operated at the wasteful level of 1973, **we would be importing four times as much oil and spending an extra $150 billion per year** for energy.

- The U.S. economy can **still achieve large, cost-effective improvements in energy efficiency.** In addition to the gains of the past decade, energy efficiency can still **increase at least 30 percent** across all sectors of the economy.
- **Federal R&D programs have played an important role** in bringing about these savings, and **can contribute even more in the future.** The case studies in Part B show how federal support for energy conservation R&D, by advancing the commercial adoption of new technology, saves billions of dollars for industry and consumers. For these seven case studies (see **Table A.1**), federal investments totaling $16 million generate eventual savings of **$68 billion—a return on the taxpayers' investment of 4400 to 1!**
- Continued advances in energy-saving technology can play a key role in **assuring the competitiveness of U.S. industry** in the world market. Experience shows that well-conceived federal R&D can reinforce private industry initiatives. Conversely, a federal retreat may open the way for aggressive firms overseas—often with their own governments' backing—to gain the edge in both U.S. and world markets.
- **The federal government has a vital role** in carrying out energy conservation research, development, and technology-transfer. Without active federal participation, important technological advances would often be hampered by industry fragmentation, market structure, or the non-capturable ("public good") nature of basic research. Both U.S. industries and consumers benefit directly from energy conservation R&D, but if the federal government withdraws, the private sector cannot take up all the slack.
- Federal energy conservation R&D **contributes significantly to the underlying policy objectives of the Gramm-Rudman-Hollings legislation**: the easing of pressure on capital markets, in order to free up funds for productive investments. Disproportionate cuts in these programs would thus undermine the aims of our national economic policy.

These views are strongly supported by the recent report on Long-Range Energy R&D Strategy, prepared by the Demand Subpanel of DOE's Energy Research Advisory Board. [ERAB, 1986] The next sections examine each of the above points in more detail. Then, in Part B, we present a series of case studies of the enormous payoff from R&D on buildings-sector energy technologies.

1. Increased Energy Efficiency is an Important National Goal

Over the past decade, Americans have developed a broad consensus on the goal of improving energy productivity throughout the economy. Both the current and previous Administrations and the Congressional leadership of both Parties have properly emphasized energy efficiency as a cornerstone of our national energy policy.

Perhaps less well-known is the enormous progress made to date. Where would we be today without the significant changes in energy efficiency achieved over the past decade?

Figure 1 provides a broad perspective. If energy use per unit of GNP were the same in 1984 as it was in 1973, the U.S. would be spending 35 percent more for energy—an **extra $150 billion per year**. Slower growth in energy demand has meant a savings of 13 million barrels/day (oil equivalent) in our current needs for oil and gas, representing nearly **three times our total U.S. oil imports.**

Had we not made these substantial gains in energy productivity, our present energy situation would look radically different. We would be facing $150 billion per year in extra energy costs, and additional oil imports of 13 million barrels/day. In consequence, our trade deficit problems would be even more severe. Oil prices would still be high, since this extra U.S. demand would maintain the pressure on world supply at the margin. OPEC would still play a dominant role; our major sources of energy supply would be far more vulnerable--as would our strategic position in the Middle East. The economy would continue to suffer from high prices of energy-intensive goods and services. Finally, the public would be clamoring for solutions to all of these problems, in an atmosphere of even more severe budget imbalance.

Since energy demand growth has been reduced, the present U.S. energy situation is manageable, at least for the near future. Clearly, market forces have played a major role: slower economic growth has helped to dampen energy demand and higher energy prices have discouraged many wasteful practices by industry and consumers. A substantial contribution, according to DOE-sponsored studies, has also come from increased technical efficiency in homes, automobiles, and factories—partly in response to price signals but also reinforced by government policies and programs. For example, increased fuel economy of cars and light trucks, compared to 1972 levels, saved an estimated 3.1 quads[1] of fuel in 1984, worth over $18 billion to consumers. [DOE/OPPA, 1985]

The good news is that we do not face an energy crisis today. The bad news is that, faced with a short-term oil glut, we run the risk of ignoring the future consequences of a finite supply of world oil reserves. How effectively will we use the "breathing room" we have earned? And, in the meantime, how long must we continue to pay for the wasteful patterns of energy use that are built into the existing capital stock?

2. Large Increases in Energy Efficiency Can Still be Achieved

The lower rate of energy demand growth that has occurred since 1973 (Figure 1) might suggest that most of the waste has been squeezed out of the U.S. economy. This is not the case. To date, much of the reduction in demand growth has resulted from belt-tightening and changes in wasteful patterns of behavior. Only a portion of the savings have come from investments in improved, energy-efficient technology.

Numerous studies suggest that, in addition to the gains already made, the U.S. could reduce its present annual energy bill from $430 billion to $300 billion or less, by adopting only those efficiency measures that are now available and economically justified. [SERI, 1981; Texas PUC, 1986; Meier et al., 1983] Most of the U.S. stock of energy-using equipment and buildings was put in place when energy prices were low, and stock turnover is slow in many sectors. So it is not surprising that much of the existing physical plant wastes energy.

It is important to note that these opportunities for cost-effective energy savings are **not affected much by the recent decline in world oil prices.**[2] This is especially true

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[1] 1 quad = 10^{15} Btu; total U.S. primary energy use is about 74 quads.

[2] Overall conclusions from the studies cited would change very little if they were updated to 1986 conditions. Oil prices would be lower in the near-term, but gas and electricity price assump-

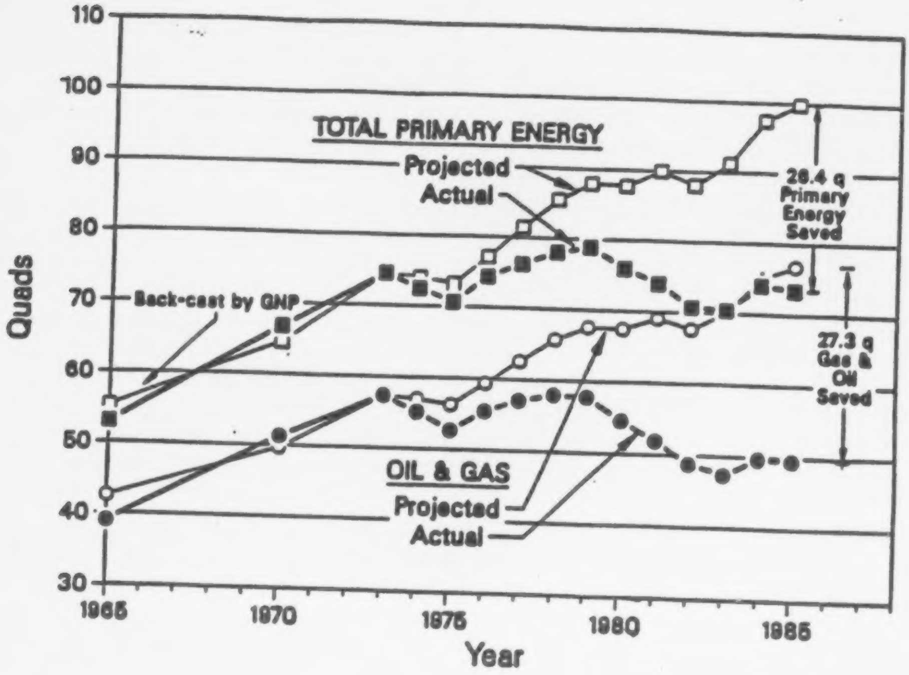

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Figure 1. U.S. Energy Use, Actual and Projected by GNP. Projected energy calculated based on GNP, in constant $, with both forecast and back-cast values from 1973. Note how well GNP back-cast follows the actual consumption curve before OPEC. The 74 q used in 1984 cost end-users $430 B. Source: Monthly Energy Review published December 1985 and EIA Annual Report to Congress.

for the buildings sector, which is increasingly electricity-intensive (in 1984, U.S. buildings consumed $100 billion of electricity but only $65 billion of oil and gas). Nationally, retail electricity prices are quite insensitive to changes in the cost of oil (or natural gas). This point is illustrated in **Figure 2**, which shows powerplant fuel costs, in constant dollars, as a fraction of the average U.S. retail electricity price, to all sectors, from 1980 through 1985.

Figure 2 shows that, while the overall cost per kilowatt-hour has changed very little in the past six years in real dollars (after inflation), fuel costs actually declined from 35 percent of the total to 26 percent. This decline was roughly offset by increases in other utility expenses, notably the rapid rise in capital costs for new powerplants entering utility rate-bases. Oil costs for electricity generation have declined even more dramatically than total fuel costs, largely due to fuel-shifting and replacement of older oil-fired plants. **Oil now represents, on average, less than 3 percent of the total retail price of electricity**, or about 2/10 of a cent per kilowatt-hour. Thus, even if the *average* oil price paid by electric utilities—not just the well publicized spot-market price—were cut in half, there would be almost no noticeable effect on the average price of electricity paid by U.S. consumers.

There are still important gains to be made in the fuel efficiency of buildings and equipment, but in the future, energy conservation R&D for the buildings sector will increasingly emphasize more efficient use of electricity, including the shifting of loads from peak to off-peak periods. As we have seen, the economic value of these electricity conservation and load-shaping measures will not be affected significantly by oil price changes, regardless of their magnitude.

How does today's energy use in the U.S. compare with that of other industrialized countries? The answer is that, per unit of GNP, we still use as much as 75 percent more energy than some of our major trading partners—and competitors. Japan and France, for example, each spend about 6 to 7 percent of their gross national product on energy, compared with 11.2 percent for the U.S. [IEA, 1985]

A key issue for the 1990's is whether capital investment in *new* facilities and equipment is as energy-efficient as it could be, in light of current energy prices and technology. The short answer is no; on average, today's new capital investments are still far from optimal. A typical new building, which will be in use for the next 50 to 75 years, still requires almost twice as much energy as one designed and equipped to minimize the total costs of energy, construction, and operation. [Piette et al., 1986]

Energy efficiency of the average new household appliance is also well below that of the best unit available--and even farther below the level of performance that is technically achievable and economic. **Figures 3a** and **3b** show these relationships for energy use in 1985 by: (1) the average gas and electric appliance in all U.S. households, (2) the average new appliance purchased, (3) the most efficient unit available on the market, and (4) an estimate of the best unit that could be made available to consumers in the mid-1990's. The Figures show that, in many cases, today's best product is already 30-40 percent more efficient than the average new unit purchased. Within a few years,

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tions in the studies are still valid. Also, several energy-saving technologies not previously considered are now commercially available.

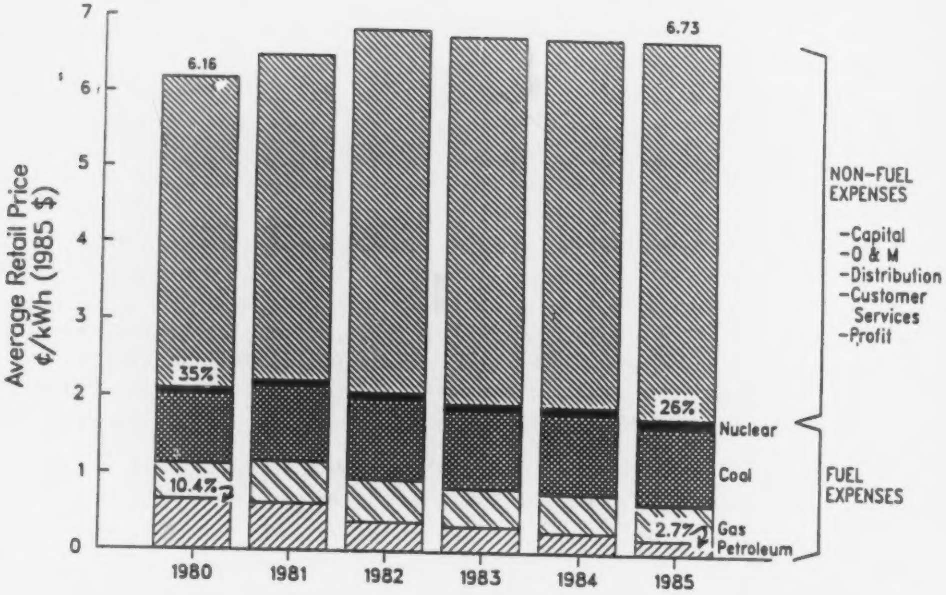

Figure 2. Fuel expenses as a component of the average U.S. retail price of electricity (in constant 1985 $), 1980 to 1985. Note that in real dollars, the average electricity price per kilowatt-hour (to all sectors) has changed little in six years, while the fuel component has declined from 35 percent to 26 percent. Non-fuel expenses, especially capital costs of new powerplants, have offset lower fuel costs. Oil costs have dropped even more dramatically, from 10 percent in 1980 to less than 3 percent in 1985. Even if the average cost of oil to utilities were to drop 50 percent, the average retail price per kWh would decline by only about 1/10 of a cent. Other cost increases would quickly offset any such decline.

industry leaders could be marketing household appliances that reduce energy use by another 40-50 percent.

For an individual appliance, the energy savings may be modest, but the aggregate numbers are impressive. One year of electric appliance sales represents the amount of energy produced by six large, 1000-MW baseload powerplants. This would drop to two powerplants, if all new models were as efficient as the best projected 1990's technology shown in Figure 3b.

A similar story can be told for energy-using capital equipment in industry: typical energy consumption of new stock could often be reduced dramatically with cost-effective investments [Ross, 1985]. Similarly, the fleet-average efficiency of new automobiles could be raised from 27 mpg to about 40 mpg at a cost of under $1/gallon of gasoline saved. [Fahrenwald and Herendeen, 1982; Bleviss, 1984]

In summary, the best buildings, appliances, and cars now on the market are already 30-40 percent more efficient than today's average stock, but the gradual introduction of this technology will not get the U.S. ratio of energy/GNP down to the level of Japan or France. To achieve that, in the next 20 years, will require pressing forward with technology now on the drawing board—in other words, maintaining a strong national R&D program targeted to industry's needs. In the next sections, we discuss the past successes and future potential of the federal program.

3. The Federal Energy Conservation R&D Program Has Achieved Dramatic Successes and Holds the Promise of Continued Success

We now turn to the basic issue: how well has the federal R&D program served the nation?

Table A.1 quantifies the dramatic returns on investment generated by DOE-sponsored R&D in the buildings sector. Additional detail is provided in the case studies in Part B of this paper. Each of these technologies will yield extremely large payoffs once they reach market saturation; three had already demonstrated significant commercial success by 1985 (solid-state ballasts, low-emissivity window films, and heat-pump water heaters).

By way of example, let us consider the first three technologies in Table A.1: solid-state ballasts, low-emissivity window films, and residential absorption heat pumps.

- The total government cost of these three projects is less than $12 million, thanks to DOE cost-sharing with private industry.
- Two of the three projects (the third is not yet commercial) have already produced annual net savings[3] far greater than the total federal R&D investment over several years. In other words, a *one-time* federal investment of $5 million for the two projects has already generated an *annual* return of $25 million—or over 500 percent per year.
- The near-term benefits are small, however, compared with the eventual impact from full market saturation of these new technologies. Taken together, they

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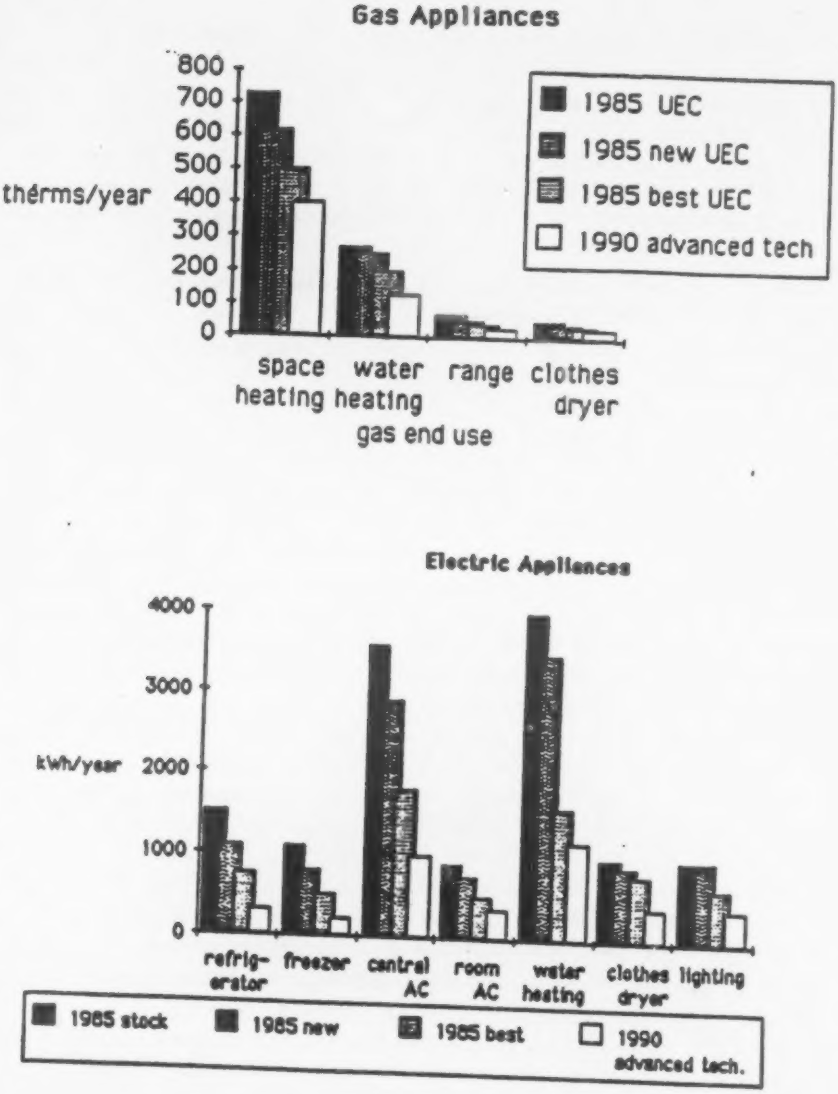
[3] Net savings = annual energy savings minus the increase in (annualized) capital cost to buy the more efficient products.



Figures 3a and 3b. Unit Energy Consumption of Gas and Electric Household Appliances in the U.S. Each set of bars compares energy use by the average model in the 1985 stock, the average new unit and best new unit sold in 1985, and the best technology expected to be available in the 1990's. For scale, note that the electric appliances sold in just one year use as much electricity as is produced by six large, 1000-MW powerplants. This would drop to two powerplants if all new models were as efficient as the best 1990's technology. Source: H. Geller, American Council for an Energy Efficient Economy

will ultimately save U.S. consumers over $10 billion per year.

- However, we must assume that, eventually, these technologies would have been developed commercially even without federal R&D support. The government should take credit only for accelerating the market—by about 5 years, in these three cases. Thus, the net benefit of federal involvement in these three projects is 5 years times $10 billion/year, or roughly $50 billion. This represents **an extraordinary 4000 to 1 return to the taxpayer on an initial investment of only $12 million.**

The other projects shown in Table A.1 also show substantial net savings, and handsome returns on the federal R&D investment.

Table A.1 illustrates another important point: the long lead-times involved in research, development, and successful commercial adoption of a new technology. DOE research on solid-state electronic ballasts, for example, began in 1976 and lasted until 1980. Despite relatively high turnover rates for replacing fluorescent ballasts, it will probably take until the mid-1990's for them to reach 50 percent market saturation. This perspective makes it clear that well-targeted R&D can have a major impact if it advances the eventual commercialization date by only a few years.

Additional examples of high-impact R&D projects are provided in the 1985 DOE Conservation Multiyear Plan. **Table A.2**, reproduced from the DOE Plan (page 12), contains a list of 18 projects, mostly from the industrial sector, that have led to new technologies that are commercially available today. All were supported, fully or in part, by the DOE conservation programs. DOE estimates energy savings from these 18 projects at approximately $16 billion *per year* by the year 2010.

There are still other examples outside the industrial sector. For example, DOE-sponsored R&D on advanced ceramics for turbines and other vehicle engines could generate well over 1 quad of *annual* fuel savings by the year 2015, representing benefits of over $7 billion/year. All this for a projected total federal investment of $239 million. [Johnson, et al.]

Energy efficiency research, as these examples make clear, is far from an academic exercise. The total federal investment in energy conservation research, less than $200 million per year, has already paid off dramatically in bottom-line economics.

These statements should not be misunderstood to suggest that all government energy conservation research projects are successful. Many projects have succeeded, as documented in Tables 1-2 and in the case studies (Part B). But others have failed to work as hoped, or have been slow in achieving commercial acceptance. This is inherent in research programs--in fact without such risk factors there would be less justification for federal involvement.

However, this same point illustrates an important advantage of R&D on end-use energy efficiency: R&D efforts are *diversified*, so the consequences of a single failure can be offset by other successes. By contrast, when government or private resources are concentrated on a few large-scale projects—as with some energy supply technologies—any failure or setback becomes all the more costly, in terms of both wasted dollars and lost time.

Table A.1. Lead-times and Net Savings for Successful DOE-Sponsored Buildings Energy R&D Projects.

	Solid State Ballasts	Low-E Window Films	Residential Absorption Heat Pump	Advanced Electric Heat Pump	High Efficiency Refrigerator Compressor	High Efficiency Refrigerator -Freezer	Heat Pump Water Heater
1. DOE Project Duration	1978- 1980	1976- 1990[D]	1978- 1988	1977- 1986	1977- 1981	1978- 1983	1977- 1982
2. Est. 50% Penetration of Sales	1995	2000	2001	1998	1990	1996	1995
3. Years by which DOE advanced commercialization	5 yrs.	5 yrs.	5 yrs.	2 yrs.	2 yrs.	2 yrs.	3 yrs.
4. Cost of Conserved Energy, (CCE)	2¢/kWh	$2/MBtu	$2.50/MBtu	$2.75/MBtu	1¢/kWh	3¢/kWh	3¢/kWh
5. Cost of DOE Project	$3M	$2M	$6.8M	$2M	$1M	$0.8M	$0.7M
6. Net Annual Savings in 1985	$11M	$14M	$0M	$0M	$0.4M	$0.2M	$6.5M
7. Net Annual Savings at Saturation (i.e. 10-15 after 50% penetration)	$5,000M	$3,000M	$2,400M	$2,500M	$1,100M	$850M	$3,000M
8. Cumulative Net Savings (Line 7 x line 3)	$25,000M	$13,000M	$12,000M	$5,000M	$2,200M	$1,700M	$9,000M
9. DOE Project ROI (Return on Investment, =Line 8 ÷ line 5)	8,000: 1	7,000 : 1	1,500 : 1	2,500 : 1	2,000 : 1	2,000 : 1	13,000 : 1

Notes:

A All dollar savings in energy costs are net of increased costs for purchase of the improved equipment (ballast, window, etc.).

B Line 4. Cost of Conserved Energy, CCE. We use a real discount rate $d = 7\%$, and the useful life of the product: e.g. - 10 years for ballasts, 20 years for windows. The CCE of low-E films, now still a novelty, is currently $4/MBtu, but as the market matures, we estimate that the CCE will drop to $2/MBtu.

C. Line 7. Net Annual Savings at Saturation are in 1985$, uncorrected for: growth in the building stock, changes in real energy costs, or discounted future values. We decided not to account explicitly for these three factors, since all three are uncertain and their combined impact probably small, as shown by the following calculation. To translate savings in 2000 or 2010 to 1985 terms, one multiplies by: $\exp[(g + e - d)T]$, with the following annual rates:

$$\left.\begin{array}{l} g = \text{growth rate of building sector (3\%)} \\ e = \text{real price escalation for electricity or fuel (1-2\%)} \\ d = \text{real discount rate (4-7\%)} \end{array}\right\} \quad g + e - d = (-3 \text{ to } +1\%)$$

T = years between 1985 and the est. saturation date, 20 - 25 years.

D. As indicated on line 6, 70m sq.ft. of first generation soft-coat were already installed in 1985, but this soft-coat can be used only between sealed double glazing. Current R&D aims to increase the durability and applicability of sputtered coatings and to produce additional engineering data to better utilize the coatings in sunbelt climates and in commercial buildings.

Source: See case studies, Part B.

TABLE A2 Selected Completed Conservation Technologies
(Partial List)

Technology (Year Completed)	10^12 Btu/ Year*	10^6 $ Savings**
Cogeneration-Coal Fired Steam Turbine (1983)	344	1,720
Cogeneration-Slow Speed Diesel (1983)	516	2,580
Computer Controlled Oven (1981)	228	1,140
Controlled Speed Accessory Drive (1981)	31	155
Cupola Stack Air Injection (1981)	25	125
Dye Bath Reuse (1979)	19	95
Foam Finishing (1980)	52	260
Heat Exchanger-Dryer (1982)	59	295
Heat Pump Water Heater (1980)	410	2,050
High Efficiency Welding Unit (1979)	42	210
Nitrogen-Methanol Carburization (1981)	10	50
ORC Bottoming Unit (1981)	225	1,125
Plastic Wastes to Fuel (1982)	88	440
Plating Waste Concentrator (1981)	22	110
Recuperators-AiResearch (1979)	178	890
Recuperators-GTE (1979)	247	1,235
Slot Forge Furnace (1978)	20	100
Solid State Ballast (1980)	660	3,300
Totals:	3,176	15,880

---

* Estimates of national energy savings projected in the year 2010, given the market penetration performance history of these technologies.

** The projected annual dollar value of energy savings in the year 2010 estimated at $5 per 10^6 Btu.

Source: FY 1987 Energy Conservation Multi-Year Plan, July 1985, Office of Conservation, US DOE.

[Editor's note, Table A2. This table, reproduced from the DOE Multi-Year Plan, shows gross savings of $3.3 B from solid-state ballasts in 2010. Our estimate in Table 1 is that net savings, at saturation, will be about $5 B. The difference is due to three factors, in addition to the gross vs net savings discussed in notes to Table 1: (1) We assume actual 1985 average electricity costs (7.5¢/kWh) while the DOE document assumes 4.5¢/kWh (based on $5/MBtu for all energy). (2) We assume eventual full saturation of the 250 BkWh used for fluorescent lighting in the U.S. in 1985; DOE's assumed baseline usage is 200 BkWh. (3) Our figure assumes 33% average savings, including reduced cooling loads and savings from improved control of lighting levels; DOE assumes an average savings of 25% per ballast.]

4. Advances in Energy-Efficient Technologies Are Needed to Assure a Strong Competitive Position for U.S. Industry in the World Market

The previous section identified a number of advanced energy efficiency technologies with strong commercial potential. But who will be the technological leaders in these growth sectors, U.S. firms or their overseas competitors? The answer depends, in part, on a continued strong federal role in advanced technology R&D.

Three contrasting examples from the lighting industry illustrate this point. The first involves electronic ballasts for fluorescent lights. As discussed in Part B, DOE-supported ballast R&D played a key role in reducing technical risks, sharing information with the industry, and helping U.S. firms to bring a new product to market so as to maintain their strong domestic position.

A similar DOE-industry research program on compact, screw-in fluorescent lamps was halted in 1981--while still in its formative stage--due to federal funding cuts. By 1985, a number of Japanese and European firms were already well ahead of their U.S. counterparts in introducing advanced, high-efficiency lamps. The Illuminating Engineering Society of North America publishes an annual list of new lighting products; in 1985, 12 of the 50 items were introduced by overseas firms.

The third case is still hanging in the balance. It involves lighting controls, a market with very high growth potential over the next few years. Recent DOE-funded research has again provided much of the technical foundation for U.S. companies to establish a position of market leadership. With continued federal support, the opportunity exists for a highly successful DOE-industry collaboration to take advantage of this multi-billion dollar market.

We find a similar pattern in another high-technology product line: efficient electric motors and controls. U.S. industrial, commercial, and residential consumers pay about $80 B/year for power to run electric motors. Recent advances in magnetic materials and power electronics are greatly improving the efficiency of these motors and motor-driven systems and reducing costs to consumers. Permanent-magnet motors, for example, can have 20 percent lower losses than the best induction motors, run cooler, are smaller and lighter, and are more precisely controlled. Current applications include machine tools, robotics, computer peripherals, and home appliances.

A recent study (Baldwin, 1986) points out that:

> U.S. competitiveness in this rapidly growing market for new motor technologies is of concern, however. As pointed out by the National Materials Advisory Board, 'The fundamental work leading to the REPMs [Rare-Earth Permanent Magnets, such as SmCo] was done largely in the United States... but after government support ceased, materials R&D in the U.S. magnets industry deteriorated. Practically all recent PM materials have been developed to commercial maturity in Japan.'
>
> Thus, the NMAB concludes that 'despite the critical importance of magnetic materials, the U.S. is rapidly losing its competitive position.' And this in a market that is expected to reach $2B annually next year.

A final example is in the area of housing technology, an industry that is traditionally seen in the U.S. as fragmented and slow to accept technical innovation. Contrast our situation with that in Sweden, where the government supports an ambitious R&D

program in all aspects of basic and applied building technology. [Schipper, et al., 1985] Total funding is of the same order of magnitude as that in the U.S., even though the domestic market is only about one-twentieth the size of ours. Swedish researchers have produced a host of technical innovations that are already used in "superinsulated" houses around the world. Applications of R&D results to an industrialized building sector have made high-quality, energy-efficient homes the norm in Sweden, rather than the exception. Several firms are now exporting their factory-built housing to the U.S., and beginning to compete successfully in upscale markets.

These examples show the commercial importance of energy efficiency technologies. The opportunities are there; the key is how to help U.S. industries position themselves to best advantage. Part of the answer lies in basic and applied R&D, where the federal government, as discussed in the next section, is a crucial player.

5. There is an Essential Role for the Federal Government in Energy Conservation Research

Both private and public sector R&D is an investment in the future. Industries and nations that invest too little in R&D, or fail to pursue valuable projects to completion, will suffer losses in competitiveness, innovation, and productivity. Such losses are not always apparent for some years, but a lack of high-quality R&D inevitably cripples industries and can weaken whole economies.

Comparative data shown in **Figure 4** demonstrate that other industrialized countries often give much higher priority to government investments in energy efficiency R&D than does the U.S. [Ketoff, 1986] Using one index, conservation R&D spending per Quad of energy use (light cross-hatching in the Figure), the U.S. ranks fifth among the five countries shown. An alternative index, R&D spending as a fraction of GNP (dark cross-hatching), the U.S. ranks third—but still well below levels for France and the U.K. If the French government's program for energy conservation R&D were scaled to the U.S., it would represent between $260 and $380 million per year (according to whether the scaling factor is GNP or energy consumption). [AFME, 1986] This compares with actual U.S. conservation R&D expenditures of only $171 million for FY 1986 (including information and technology transfer), which would be further cut to $71 million under the proposed FY 1987 budget.

There are widely differing views on the appropriate federal role in energy conservation R&D. We generally concur with the following policy statement in the DOE Energy Conservation Multiyear Plan:

> The federal role in energy research and development is concentrated in areas where the incentives for and availability of private investment are severely limited or nonexistent. ... The success of federal research and development programs in providing options for private investment and commercial development depends on effective technology transfer.

DOE defines a role for federal research and development in those areas where there is little incentive or few resources available to the private sector. This policy must be interpreted in light of recent findings on the limited extent of private R&D investments in many sectors of U.S. industry. A recent study of appliance manufacturers and markets worldwide showed that U.S. firms spent only 1-2 percent of their 1983 sales revenue on all R&D (not just energy efficiency), in contrast to an estimated 3-4 percent spent by

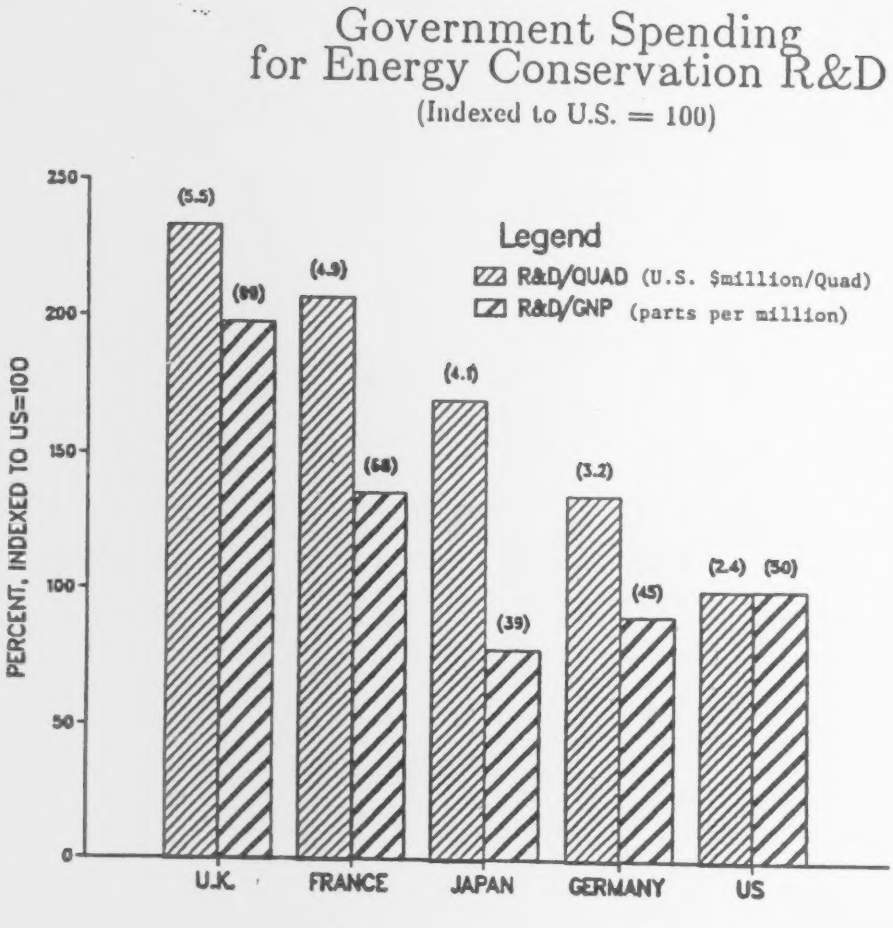


Figure 4. Government spending for energy conservation R&D in five industrialized countries. The data show that other industrialized countries often give higher priority to government spending on energy efficiency R&D than does the U.S. One index (light cross-hatching) is conservation R&D spending per Quad of energy use; the U.S. ranks fifth among the five countries shown. A second index (dark cross-hatching) is R&D spending as a fraction of GNP; the U.S. ranks third—still well below levels for France and the U.K. Source: Ketoff, 1986

Japanese appliance manufacturers. [Sterling Hobe Corp., 1984] For comparison, rapidly advancing "high-tech" industries in the U.S. typically allocate 4-7 percent of revenues to R&D. [*ibid.*]

Other reviews of R&D in the manufacturing sector find that private firms often have limited incentive or resources to undertake their own research because of high up-front costs, risks of failure, and uncertain competitive advantage from a new advance, which might be rapidly adapted or copied by other firms. Nor is it apparent that the modest federal tax incentives provided for industrial R&D have had any significant impact. [Baily and Chakrabarti, 1985]

With regards to the building industry, the recent ERAB Demand Panel report states that:

> Many small design firms, building companies, and component manufacturers comprise the building industry. Most private firms will undertake basic R&D activities if there are substantial and immediate monetary gains for the firm, and this is seldom possible in a fragmented industry of small firms. As a result, too little R&D is performed and [it] must be supplemented by the government if it is to be accomplished on any substantial scale.

The FY 1987 budget proposal urges DOE to immediately initiate joint programs with private industry, presumably to make up part of the large cuts that are planned. Collaborative, cost-shared research is generally a sound idea, and in many cases is already a feature of successful DOE-sponsored energy efficiency R&D. The flaw lies in assuming that DOE's industry partners will be willing or able to *increase* their participation, to make up for drastic reductions in federal support. In fact, the opposite will more likely occur: the private sector will be likely to reduce its own participation in step with any withdrawal of federal R&D support.

Our discussions with industry R&D leaders, including the two largest industry organizations doing research on energy efficiency (the Electric Power Research Institute and the Gas Research Institute) reveal no prospect of private industry funds that might substantially replace federal funding. Even if such private funding could be generated, it would take many years to change industry priorities and to organize new collaborations between the federal government and individual firms or industry research establishments.

We need to underscore one other essential element of DOE-funded R&D: the work on more fundamental, "technology base" activities, as opposed to specific products or devices. The result of this research is more difficult to quantify than the product-oriented R&D discussed above—but no less crucial. Industry depends on such government-sponsored research to provide a technology base upon which it can build innovative, marketable new products. The long-term nature of such research, the highly specialized expertise required, and the lack of directly marketable products limits the ability of most industries to pursue it, in the absence of a leading federal role. DOE has been successful in this role in the past, and must continue its support at an appropriate level.

Finally, the DOE Multiyear Plan points to the benefits of a federal technology transfer program. We agree; successful R&D needs to get into the market in order to have an impact on more efficient use of energy. Technology transfer is important and deserves adequate support. While some technology transfer occurs as built-in part of projects that DOE co-funds with industry in other R&D categories, we note that the entire budget line item "Analysis and Technology Transfer" has been reduced to $1 million in the proposed budget. This is totally inadequate for any meaningful national program.

To summarize, we endorse DOE's stated policies on the appropriate federal roles for purposes of our discussion. The issue, as stated, is one of appropriate level of government support. This depends in turn on an assessment of the magnitude of the problem, and the degree to which government activities can solve it. The problem is surely large—we are wasting $150 to $250 billion per year, and facing increasing competitive pressures from overseas industries, and depleting our own oil and gas reserves at a rate that is proportionately 8 times faster than that of the OPEC countries. [Flavin, 1985] Federal support of energy conservation R&D is a key to addressing these problems over the long term.

6. Federal Energy Conservation R&D Contributes to Underlying Policy Goals of a Lower Budget Deficit

The Gramm-Rudman-Hollings legislation recognizes the urgency of reducing the federal deficit. Why? A burgeoning national debt means higher interest rates, which threaten to stifle economic growth by competing with the private sector for available capital.

But the federal deficit is not the only drain on investment capital. The U.S. energy sector itself accounts for only about 12 percent of GNP, but represented 40 percent of total investment in plant and equipment expenditures, for all sectors, in 1982. [Goldenberg, et al., 1986] From 1979 to 1984, the oil industry invested $250 billion in oil exploration alone, without achieving a net increase in U.S. reserves at the end of the five years (i.e., new discoveries just offset production). From 1973 to 1984, the electric utility industry invested $300 billion in new power plants. The single largest drain on investment dollars—after the federal deficit—is the investment in new energy supply.

Greater efficiency in energy use also means that less capital is needed for new energy supply facilities. Of course, energy-efficient technologies also require capital investments, but these are almost always several times lower, per barrel of oil or per kilowatt-hour, than investments required for traditional sources of energy supply.

In short, *increased energy efficiency can make a significant contribution to the objective of increased capital availability and lower inflation rates that are underlying goals of a reduced federal deficit.* It makes no sense to disproportionately slash federal funds for energy conservation R&D, in the name of the very policy goals that are best achieved by energy efficiency.

Conclusion

As we have seen, the proposed 50+ percent reductions in federal energy conservation R&D funding carry a double penalty for the U.S. economy and all consumers:

(1) Given the lead-times of 20 years or more for development and commercialization of advanced energy-saving technologies, **we cannot afford to abandon or defer the R&D investments that are needed now** for long-term economic vitality.

(2) Many R&D projects also have near-term payoffs. Even with a (temporary) softening of world oil prices, we can continue to **save billions of dollars each year** from the earlier introduction of energy-efficient technologies. Reducing the nation's energy bill makes our industries more productive, slows inflation, reduces our trade deficit, and gives each consumer more money to spend in job-creating sectors of the economy.

The projected impacts and high leverage of DOE R&D funds are discussed in some detail in the preceding sections and in the case studies to follow. DOE's current R&D program contains numerous projects with the same potential for success as those already completed. These projects and their rationale are described in several DOE reports, including the Multi-Year Plan. The data provide convincing evidence of the enormous value, both now and in the long run, of a well-formulated energy conservation research effort.

We recognize that controlling the federal deficit requires strong, even painful, action. However, activities that have demonstrated their success in meeting important national needs—including the objectives of federal deficit management—must be recognized. The federal role in energy conservation R&D falls into this category. We must maintain the momentum, to avoid crippling the nation's prospects for energy and economic security in the 1990's.

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FEDERAL R&D ON ENERGY EFFICIENCY
A $50 BILLION CONTRIBUTION TO THE U.S. ECONOMY

A White Paper on the Consequences of Proposed FY 1987 Budget Cuts

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PART B: CASE STUDIES OF R&D ON ENERGY EFFICIENCY IN THE BUILDING SECTOR

This section recounts the development of seven energy conservation technologies in lighting , windows, and appliances. In hastening the commercialization of these technologies by two to five years, federal conservation R&D will save U.S. consumers $68 billion over the next 25 years.

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SUMMARY

Part A of this White Paper explains the compelling economic and security reasons for maintaining federal energy conservation R&D at least at current funding levels.

If Americans consumed as much energy today per dollar of GNP as they did in 1973, the U.S. would in 1986 be importing four times as much oil as we are now and spending an extra $150 billion per year for energy. Our trade deficit would be far worse, oil prices would have stayed high due to extra U.S. demand, and OPEC would still be a dominant force, weakening our national security and our strategic position in the Middle East. Federal programs in conservation R&D have played an important role in bringing about the $150 billion in annual savings we currently enjoy and in strengthening our economic and strategic position. Moreover, government studies show that by implementing additional efficiency measures that are cost effective at today's energy prices, the U.S. can improve its energy efficiency by 30% and save an additional $130 billion per year.

Continued federal support is needed to foster the development of new conservation technologies that will make the nation more efficient at home and more competitive abroad. Through public-private partnership, federal conservation R&D programs are stimulating efforts that industry would not undertake alone. These programs have already paid off handsomely. In Part B of this White Paper, we give seven examples of R&D successes in buildings components and equipments. By "success" we mean that the improved technology is already at or near commercial production, and will achieve 50% market penetration five to fifteen years. We can then evaluate the annual savings at market saturation, which occurs roughly 30 years after project initiation. Just these seven examples will save U.S. consumers $18 billion/year (scaled to today's economy). Since the federal role advanced this $18 billion/year by 2-5 years, we estimate that the cumulative savings attributable to DOE R&D are worth $68 billion.

The payback calculations do not attempt to estimate any additional secondary benefits which may derive from the resulting enhanced competitive position of U.S. manufacturers or from increased national energy security. Many other equally impressive success stories could be recited due to conservation research in the industrial and transportation areas. In the future we plan to add other case studies in these areas.

A typical feature of these seven cases is their low cost of conserved energy, i.e., the cost of providing the desired service by improving efficiency instead of purchasing electricity or gas. The cost of conserved electricity ranges from 1 to 3 cents/kWh vs. about 10 cents/kWh for new power today; for natural gas cost of conserved energy ranges from $2-3/MBtu vs. $6/MBtu for retail gas today. Thus, conservation has been running 2 to 10 times cheaper than new supply.

An important common element of each of these seven cases is the early involvement of private sector firms, generally through subcontracting. In most instances, private firms did most of the development. Often small businesses (sometimes very small) played a key role. They did the early development, and when the innovation was at the stage where it looked good commercially, it was picked up by larger firms through buy-out or partnership. The government R&D efforts were the catalyst in this public/private sector partnership, supplying the financial resources, technical support,

and independent evaluation through the national laboratories. This support was sustained over a sufficiently long period of time that successful market entry occurred. process could be completed.

LIGHTING

Energy-Efficient Solid-State Ballasts for Fluorescent Lighting

In 1976 the U.S. Department of Energy (DOE) established a lighting research program at the Lawrence Berkeley Laboratory (LBL) to accelerate the commercialization of energy-efficient lighting technologies. LBL researchers under the direction of Professor Sam Berman soon focused on the potential of solid-state ballasts powering fluorescent lamps at high frequency to reduce the energy needed for lighting by 15-30%. Calculations showed that if such high efficiency ballasts were to saturate the U.S. market they could save $5 billion per year by reducing energy demand by an amount equal to the output of 10 large (1000 MW) power plants.

None of the major ballast manufacturers showed any interest in the program or replied to a request for proposal (RFP) that LBL issued in 1976 for cost-sharing subcontractors to develop circuitry for the ballasts. However, about 14 small, entrepreneurial firms did apply. This pattern appears in many of the R&D case studies discussed in this document. Large established firms showed little interest in the early stages of product development, whereas small companies jumped at the opportunity to conduct joint R&D with the government. It appears that modest federal funding helped speed valuable research that large firms would not have pursued on their own initiative and which small firms working alone could not afford. The results of this public-private partnership are impressive, both for the energy savings potential they have provided to society and the business successes they generated.

In 1977 LBL selected two contractors to develop prototypes. IOTA Engineering submitted a low-cost, non-dimmable design; Stevens Electronics submitted a sophisticated high-performance design that was not only more efficient, but could also dim the fluorescent lamps down to 10% of full light output.

The first prototype delivered to LBL for testing showed that the new high frequency ballast could increase lighting efficiency 25%, by combining 15% better lamp performance with reduced transformer losses from the ballast itself. The first generation ballasts were not reliable enough, however, so LBL arranged to have a second generation prototype developed and installed for demonstration and testing at the headquarters of the Pacific Gas & Electric Company (PG&E) in San Francisco. The federal laboratory's involvement in this research lent the credibility needed to get a major demonstration program approved at such a highly visible location.

At PG&E in 1978, 500 IOTA ballasts were installed on one floor, 500 Stevens ballasts on a second, and 500 energy-efficient electromagnetic ballasts on a third. LBL monitoring confirmed that the new ballasts reduced lighting energy consumption by 25% without compromising illumination requirements. However, a considerable number of ballasts failed due to design faults that had not been identified in limited laboratory testing.

In 1979, after the design problems were corrected, commercial interest in the ballasts increased. Beatrice Foods, Inc., bought IOTA's concept and patents rights and formed a division, EE Tech, to develop and produce the product. Stevens Electronics sold their exclusive rights to Luminoptics, a company established to manufacture and market the Stevens design.

In 1979, the Veterans Administration Office of Construction proposed to co-fund with DOE a demonstration of the advanced dimmable ballast prototype in a medical center in Long Beach, CA. LBL placed over 400 ballasts supplied by Luminoptics in the medical center, measured their energy savings and reliability, and studied their compatibility with personnel and equipment. After this successful demonstration, the Veterans Administration Office of Construction became the first federal agency to specify the use of solid-state ballasts.

Throughout this period LBL published its findings and made numerous presentations to the lighting community and general public. Major U.S. ballast manufacturers continued to show little interest, although two foreign companies, O.Y. Helver (Finland), and Toshiba (Japan), began producing solid-state ballasts in 1980. From 1980 to 1984 a dozen small domestic manufacturers struggled to establish a market for high efficiency ballasts and to improve the reliability of their products. The relatively conservative lighting industry was slow to adopt these innovative designs, even though foreign firms were already entering the domestic market with energy-efficient lighting products. LBL's program support was reduced during this period, but it continued to publicize the benefits of solid-state ballasts and to test the new products for reliability. LBL also worked with the manufacturers and the Federal Communications Commission to develop voluntary standards to assure that electromagnetic radiation emitted by the high frequency ballasts would not interfere with computers, communications devices, and other electronic equipment.

By the end of 1984 one million solid-state ballasts for the F40, 40-watt lamp had been sold in the United States. Though this was a small amount in comparison to the total annual demand of 70 million units, the proven credibility of the products, in concert with LBL's R&D support, information dissemination, and technology transfer had finally brought the solid-state ballast to the brink of commercial success.

In 1984 General Electric and GTE announced a lamp that was designed to be operated with a solid-state ballast. This signified that the major lamp manufacturers recognized that an important new market was emerging. In 1985 General Electric announced a solid-state ballast, and Universal Manufacturing announced a low-cost dedicated solid-state ballast. Advanced Transformer, the largest U.S. ballast manufacturer, has just announced plans to market a solid-state ballast for two 40-watt, F40 fluorescent lamps. Small companies are still entering the field expecting to obtain a market share for special applications. The market for solid-state ballasts is expected to grow rapidly, and should achieve 50% penetration by 1990 and saturation by the year 2000.

The successful strategy and perseverence of the LBL/DOE program, with the coordinated and cost-shared investment of small companies have created a new, efficient lighting technology. The DOE funding for this program over the past nine years was only $2.7 million, approximately half of which was subcontracted, with subcontractors providing an additional $1 million.

Today, two million solid-state ballasts are in operation in the U.S., each saving on the average 25 watts for 4000 hours annually, a total of 200 million kWhs. At a typical energy cost of $0.075 per kWh, this reflects an annual savings of over $15 million: the $2.7 million DOE investment in the solid-state project has already been returned five fold. Within 30 years, the cumulative net savings from the government's participation will total approximately $25 billion. This achievement reflects how an effective DOE strategy to promote technological innovation can succeed even in a restricted environment dominated by a few large corporations with a seemingly captive market. The 1980 foreign import threat appears to have been repulsed.

Future Possibilities

The high-frequency solid-state fluorescent ballast is the key technical element allowing the more widespread application of demand control of the light output of fluorescent lamps. While standard core ballasts can dim fluorescent lamps by conditioning their input power (voltage reduction or phase control), solid-state ballasts dim lamps by low-voltage signals. This reduces the cost of the control equipment and increases the flexibity of the control system. That is, solid-state ballast control systems independently dim single lamps as well as large banks of lamps. Electromagnetic ballast systems, in contrast, can dim only large banks of lamps and at greater expense.

Thus, in addition to demand preferences, such as scheduling and lumen depreciation strategies that bring the energy savings to 30-40%, solid-state ballast dimming systems can effectively employ task tuning and daylight capture, as well as load-shedding strategies. The latter strategies can reduce energy consumption by another 30-40%. The total cumulative energy saving, considering the intrinsic gain and all the other demand strategies, has a potential savings of 60-70%, or more than double that of the best core ballast dimming system.

Cost of Conserved Energy is calculated in the last section of Part B.

WINDOWS

Advances in High-Performance Windows
The Successful Development of
Low-E Coatings for Windows

One quarter of all the energy used to heat and cool U.S. buildings—an amount equal to the entire output of the Alaska pipeline—is required to compensate for unwanted heat flow through windows. Windows were perceived as weak thermal links relative to insulated walls and roofs, and the first building energy guidelines developed in response to the energy crisis responded to this perception. In addition to requiring greater use of double glazing, their intent was to reduce window area, regardless of desires for windows in living and working spaces. The crisis-oriented prevailing wisdom assumed that the only way to save energy was to sacrifice amenity and comfort.

Recognizing this, in 1976 the U.S. Department of Energy (DOE) initiated a program at Lawrence Berkeley Laboratory (LBL) to develop guidelines for more efficient use of windows and to develop more energy-efficient window components and window systems. LBL researchers, under the direction of Stephen Selkowitz, set out to develop a window that would look like a window, admitting light, views, and useful solar heat gain but behave thermally more like an insulated wall. They calculated that if a selective window coating could be developed that was transparent to visible light and solar radiation but blocked heat flow, energy loss through windows could be dramatically reduced.

In 1976 the principle behind such low-emissivity (low-E) coatings was understood, but no commercial low-E products were available. Some manufacturers knew about the potential of such coatings, but they doubted that durable products with adequate optical properties could be produced at low cost and high volume. With other issues apparently more pressing at the time, the R&D programs of the window industry essentially ignored low-E coatings. It wasn't until the federally funded research program demonstrated the promise of this technology that the window industry began to aggressively develop and ultimately market low-E products.

The $2 million federal investment went a long way, stimulating over one hundred million dollars in private sector investment in low-E film production technology. In 1985, low-E window coatings were commercially available and saving consumers $14 million per year on their energy bills. By 1995, low-E films are expected to capture over half of the window market and yield annual heating savings of $120 million. And by the year 2000, cumulative energy savings from low-E coatings for the residential sector alone should exceed billions of dollars.

This dramatic advance in window technology began with a series of research grants that LBL issued with DOE funding to several small research firms in 1976. Their task was to investigate potential coating systems and deposition processes for low-E films. LBL undertook studies to determine the optimal use of coatings within the multi-element window system and to determine the potential benefits of these hypothetical windows in residences. Extensive conversations and meetings were held with key actors in the window industry and limited market studies were completed to better understand the fit between various window designs with low-E coatings and the complex structure of the window industry. These studies were important since the coatings were likely to be developed and sold by glass companies or specialized fabricators, while the windows would ultimately be sold to specifiers and homebuilders by the window manufacturers, who, as a group, lacked experience and confidence in sophisticated coating technology. LBL completed building simulation studies to estimate the benefits of this new technology and presented results to meetings of architects and engineers to try to build a market interest and demand for the products.

After several years of DOE research support, one of the small firms developed a coating technology to the point where they were able to attract venture capital to build their first production facility. Southwall Technologies, formerly Suntek Research Associates, was originally interested in the huge retrofit market and thus developed a low-E coating and deposition process for thin plastic films. While their initial product had excellent optical properties and achieved the initial goals for low emittance (.15) and transmittance (>70%), it did not have adequate durability to be used in retrofit applications exposed to air and dirt, so they turned their attention to a sealed window unit incorporating a coated plastic film stretched across the air space of a conventional double-glazed window. Since the window design had two air gaps, the U-value (heat transfer rate) of this window (.23 Btu/ft2-hr-oF, or more than R-4) was even better than that of a simple double-glazed unit with a low-E coating directly on the glass surface. But the use of plastic in the sealed glass unit and the additional cost and complexity of incorporating a smooth, taut plastic film stretched across the air space turned out to be a significant obstacle to rapid adoption by the relatively conservative window industry. Since high-quality windows are expected to have a lifetime of over 20 years, these durability related-questions were very important to the window firms that would be ultimately liable for the product. By 1980 Southwall was in business of producing their first-generation roll-coated product and was working closely with several window manufacturers to develop and refine the fabrication technology to incorporate the stretched film in the window unit.

In the glass industry, coatings are applied to glass by two processes. In the pyrolytic process a coating is applied directly on the hot glass as it emerges from the float glass tank. This has the potential of very low cost, but consistent control of the process parameters in the rapidly moving production line is difficult. While simple solar reflective coatings had been applied with this process, no one had developed an adequate pyrolytic process for applying the more complex low-E coatings.

Vacuum-deposited coatings are applied in a vacuum chamber large enough to accommodate a large piece of flat glass. Maintaining good coating uniformity over large areas was difficult, and in many facilities a large percentage of the coated glass had to be rejected for this reason, thus raising costs of the finished product. The low-E coatings, which were typically three-layer designs, appeared to be even more difficult to apply without an unacceptably large rejection rate.

Early in the research program, coating technology consultants to LBL reviewed various deposition processes to determine if any had the potential to deposit the types of materials required for low-E coatings at high deposition rates and with good uniformity. A process known as magnetron sputtering appeared to meet the requirements and was gaining favor in the late 1970s for small area coating in the electronics industry. The major U.S. producer of large magnetron sputtering systems, Airco Solar Products, was in the process of trying to sell these new large deposition systems to the U.S. glass industry to produce solar control coatings for architectural applications. At that time most of the large glass producers used older vacuum coating systems that could not easily produce uniform, multilayer coatings. Based in part on the promising initial results from the DOE supported studies, Airco accelerated their R&D program to develop suitable low-E coatings that could be licensed to the purchasers of their deposition systems. This was necessary because most of the U.S. glass companies did not have the resources to undertake coating R&D and none of them had deposition systems capable of producing the coatings.

By the early 1980s several large sputtering plants had been sold to major U.S. manufacturers but none were offering a commercial low-E product. In Europe, with higher energy prices, more restrictive building standards, and a tradition of greater first cost investment in buildings, several versions of low-E coatings had been successfully marketed. One of the first Airco machines was sold to Pilkington Glass Ltd. in the U.K. and installed in Sweden where the low-E coated glass was a major product. LBL participated in an International Energy Agency Task Group on window performance with researchers from seven other European countries. This provided an opportunity to learn more about the experience with low-E in other countries, to share those insights with U.S. industry, and to apply those results to the U.S. research effort.

In the early 1980s LBL staff gave presentations at industry association meetings and trade shows, and met privately with research and marketing staff from a number of major window manufacturers to build confidence in low-E technology. Extolling the virtues of this nearly invisible product with real but invisible advantages was a challenging task, particularly since major building engineering guides like the 1981 ***ASHRAE Handbook of Fundamentals*** made little mention of low-E coatings. LBL developed new tables of heat transfer data for low-E windows, which were published in the 1985 Handbook.

Interest and confidence in low-E coatings was advanced by their use in a small test building at MIT. The facility originally used prototype windows incorporating the Southwall coated plastic. These were later replaced with the Airco coated glass product. Since low-E windows were one of several innovative building technologies being demonstrated in the facility it was not possible to isolate the effects of the low-E glazing alone. However, it was an important step in the long process of building confidence in this technology, giving many interested parties their first view of windows with low-E coatings.

Market Breakthrough

A major market break hrough occurred in 1983 when Airco installed a large sputtering plant for low-E coatings for Cardinal IG, the firm that supplies the sealed insulating glass units for the largest window manufacturer in the U.S., Andersen Corporation. This was the first time that a large glass coater had been operated in the fenestration industry by anyone other than a glass producer and it stimulated additional purchases of this type. Once Andersen announced the availability of a low-E window, the generic product gained new credibility in the eyes of consumers, builders and specifiers, and it placed additional competitive pressure on other window manufacturers. In 1984 the first significant sales of low-E glass occurred; by 1985 industry estimated that 70 million feet or over five percent of the market had been captured. The marketing directors for several major glass firms estimate that 25-50% of the residential market could be captured by 1990, a very high penetration rate for a new technology.

As market interest increased, glass manufacturers and others in the fenestration industry became more interested in new coated glass products and they invested in a number of the large sputtering plants at a cost of about $10 million each. By the mid-1980s industry had invested more than $150 million in facilities that could produce the new generation of low-E coatings, and virtually every major glass and window company offered a low-E product.

Although the product was originally developed with the northern residential market in mind, low-E coatings will also penetrate the residential sunbelt market and some fraction of the nonresidential building market. Traditional, high transmission low-E coatings can be modified to selectively transmit daylight but reject solar near-infrared to reduce cooling loads. In the sunbelt this offers control of winter heat loss and summer sun without excessive loss of view, and with greater comfort year round. Since most of the new residential construction is in the sunbelt, this application represents a major new market opportunity.

In nonresidential buildings these modified low-E coatings will also make it easier for architects to utilize daylighting to save electric lighting energy and to reduce peak electric demand charges. LBL simulation studies were the first to extensively explore the complex tradeoffs between daylighting benefits and heating and cooling loads and to make recommendations on the best coatings types for different climates. Results of these LBL studies were utilized by ASHRAE in revising their nonresidential building standards to recognize the potential benefits of properly designed and managed windows.

The proliferation of low-E coatings on the market is a sign of their commercial success, but it creates problems for designers and specifiers who may be overwhelmed by confusing and conflicting data. LBL worked with the National Fenestration Council to conduct a Low-E Industry Roundtable in August 1985, where over 100 industry representatives discussed mutual concerns. The attendees expressed an interest in developing standardized calculation procedures so that low-E claims could be compared on a consistent basis. A new DOE/LBL computer model that might assist in meeting this objective was released at the meeting. "WINDOW" allows users to calculate the thermal properties of low-E windows of almost any design to help manufacturers and designers make better window design decisions. Other DOE-sponsored projects are underway at the National Bureau of Standards to develop standardized procedures for laboratory measurement of window heat transfer, and at LBL to measure the performance of low-E windows outdoors in a new, highly accurate, mobile field test facility. Performance data from realistic field tests are essential to help validate simulation models of low-E performance, to develop reliable design guidelines and to gain the confidence of developers and specifiers of this new technology.

Sales, Costs and Savings

An estimated 70 million square feet of low-E windows were sold in the U.S. in 1985 at a retail cost $2.00-$3.00 per square foot more than normal double-glazed windows. These were primarily sputter coated on glass, although the coated plastic films are also selling well. Several U.S. glass companies have now introduced pyrolytic low-E "hard coats". These can be used on single glazing and in non-sealed multiple glazing units, thereby extending sales to the large retrofit market. The emittance properties of the pyrolytic coatings are not as good as those of the sputtered "soft coats", with the exception of one imported from Belgium by a U.S. window manufacturer. Additional coating research and development in the U.S. and overseas in the years ahead will continue to improve optical and thermal properties and cost factors. It should be possible eventually to reduce coating manufacturing costs to $0.10 -$0.25 per square foot which should reduce the additional retail cost to under $1.00 per square foot.

The potential energy savings from full market penetration of this technology are enormous. In the residential sector, windows with low-E coatings are now specified for new construction, additions, and renovations, a market with total annual window area sales of about 700 million square feet. The recent introduction of the pyrolytic hard coats provides additional opportunities in the retrofit market, such as storm windows and add-on glazings. The multitude of new low-E products and their varied potential applications makes it difficult to precisely predict their total energy-saving potential. It seems likely, however, that annual heating energy savings by 1995 will total $120 million[1] and that cumulative energy savings through 2000 for the residential sector alone may total more than $3 billion.

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[1] We estimate total savings based on the following assumptions: 1) Existing stock is a mixture of single and double glazing; 2) single can be replaced by single with low-E or by double with low-E; and 3) double can be replaced by double with low-E or by other multiglazed and gas-filled configurations with low-E. We calculate the improvement in heat transfer rate for each and derive an overall weighted average improvement of about 0.25 Btu/ft^2-hr-°F. Since our interest is in heating energy, we select a typical climate that is slightly colder than average. In a climate with 6000 heating degree days, the improved windows will reduce heat loss by about 35,000 Btu/ft^2-yr, which will save about 50,000 Btu/ft^2-yr after heating system efficiency (about 70%) is accounted for. At an average 1985 natural gas price of $6.00 per million Btu, the savings is $\$0.30/ft^2$ per year. If industry projections of capturing over 50% of the residential window market by 1995 are realized and if total annual residential window sales climb slowly to 800 million square feet this would result in 1995 low-E sales of 400 million square feet, with an annual heating energy savings of $120 million ($\$0.30/ft^2 \times 400$ million $ft^2 =$ $120 million). Actual savings will be larger since we neglect storm window retrofits and the higher value of savings in electrically heated homes and ignore potential cooling-load savings in the sun-belt. In addition, low-E glazing use in the commercial sector will further increase savings.

Summary

The U.S. Department of Energy invested approximately $2 million in research efforts to accelerate development and commercial introduction of low-E technology. This helped to leverage a much larger private-sector investment in new deposition systems and in development of new window product lines. Builders, architects, engineers, and home owners are in turn investing even greater sums to purchase and install these new systems. The ultimate benefits accrue to homeowners, in the form of lower utility bills and improved comfort and amenity; to the fenestration industry, in the form of new production technology, increased employment, and new value-added products; and to the U.S. in the form of decreased dependence on imported fuel, improved balance of payments, and maintenance of a strong building sector that can compete effectively in the international market. As individuals and as a nation it makes sound economic sense to invest in this new energy-saving technology.

Over a ten-year period the DOE-supported fenestration research program has worked cooperatively with industry to introduce a new generation of high-performance window products. The successful market introduction of windows with low-E films is important because of their enormous energy savings and because they lay the foundation for further technological breakthroughs in window designs that are the subject of current DOE-supported research.. In cold northern climates a new generation of "superwindows" will have a resistance of R-6 to R-10 and will outperform the best insulated wall or roof. In the sunbelt and many nonresidential buildings, new "smart windows" will automatically adjust their transmittance properties in response to changing climatic conditions, to energy management requirements and to varying occupant needs within the building. This will minimize cooling needs, maximize daylighting benefits, and provide the glare control, thermal comfort and privacy desired by building occupants. With these technology options and the appropriate design data to ensure their optimal use, windows and skylights have the technical potential of completely eliminating their net annual energy cost, becoming instead a net source of energy in buildings. Continued federal support of energy-efficient window research is vital to the achievement of this challenging and important national goal.

BUILDING EQUIPMENT

Introduction

The objective of the Building Equipment Research (BER) program at Oak Ridge National Laboratory (ORNL), sponsored by the Department of Energy (DOE) Office of Buildings and Community Systems, is to develop a technology base for improving the energy efficiency and load characteristics of equipment for space heating and cooling, water heating, and other appliances used in residential and commercial buildings. This program has been sponsored by DOE since 1976. During the late 1970s and early 1980s, the philosophy of DOE and its predecessor, the Energy Research and Development Administration (ERDA), had been to work on projects that showed the potential for near-term commercialization of energy-efficient appliances. As a result of the research sponsored by DOE, a number of new products were developed by manufacturers and were successful in the marketplace.

The change in administrations brought a change in philosophy within DOE, and the charter of DOE-sponsored research shifted to long-term, high-risk research with the potential for high payoffs. Under this philosophy, activities with near-term commercialization potential were phased out, and research shifted to equipment that might represent products to be introduced in the 1990s. Emphasis has been on high-risk activities that are not likely to be carried out by the private sector.

Below are five case studies. Three represent projects that were completed in the early 1980s, and resulted in more efficient products on the market. Two represent research that is currently underway and which, if successful, will result in new products in the 1990s. They represent clear cases where DOE-sponsored research was instrumental in accelerating the development of a technology. The DOE-sponsored research either produced the first product, or prompted other manufacturers to enter the market, leading to further product improvements.

Refrigerators

Under the direction of Virgil Haynes, ORNL in 1977 funded Arthur D. Little, Inc. to work with Amana Refrigeration, Inc. to design a ***high-efficiency refrigerator.*** From a list of 18 energy-saving options, six were chosen for the prototype model. These changes, including separate evaporators for the freezer and fresh food compartments, thicker cabinet insulation, improved door gaskets, relocation of the fan motor outside the freezer, and better defrost controls, were made on the existing Amana design and resulted in a 60% reduction in energy use. Twenty-five prototypes were assembled and marketed to test consumer acceptance and field performance. Response was so positive that Amana began producing the new design commercially in 1981, selling more than 16,000 units by 1983 and producing net savings to consumers of more than $200,000 per year. Other manufacturers soon followed with their own high-efficiency units.

While the Amana project was under way, ORNL also funded the Kelvinator Compressor Company to develop and field test 20 units of a prototype, high-efficiency refrigerator *compressor*. Since the compressor accounts for 70-85% of the energy demand of a refrigerator, improvements in this component were seen as critical to the goal of markedly improving the overall appliance efficiency. By implementing several design changes in the motor and suction muffler, Kelvinator was able to increase compressor efficiency by 44%. The company manufactured 30,000 of these efficient compressors and then made a business decision to buy rather than manufacture its own compressors. Those 30,000 yielded annual savings of $350, repaying DOE's cost for the project every three years. Many other manufacturers, including a production facility in China, have since adopted similar high-efficiency designs.

Heat Pump Water Heater

The concept of a *heat pump water heater* (HPWH) is decades old, but until the 1970s energy prices were too low to justify their relatively high cost. In 1976, Energy Utilization Systems, Inc., (EUS) began to develop a residential HPWH, with assistance from DOE/ORNL beginning in 1977. By the end of 1978, EUS had completed design studies and had put 12 test units through a one-year laboratory performance evaluation. A concurrent marketing study conducted by EUS indicated that an attractively short payback time could be achieved.

A 100-unit, year-long field test was then conducted with the cooperation of 20 electric utilities. This test, completed in 1980, produced useful information on the design and operating characteristics of these units. It also showed an installed average coefficient of performance (COP) of 1.93, compared to about 0.85 for conventional electric water heaters. EUS began producing HPWHs for sale in 1980, and was the first on the market with this product. Within a year, several other manufacturers offered HPWH units, and by 1984, 15 firms had entered the market. We believe that the EUS project accelerated development of this market by two to five years. HPWH sales are still very modest, with 16,000 units sold in 1985. However, the gains have been substantial, with increases of 50% in 1984 and 33% in 1985.

Heat Pumps

ORNL has devoted about $9 million to cooperative research with manufacturers and industry R&D groups such as the Gas Research Institute and the Electric Power Research Institute to advance the efficiency of *gas and electric heat pumps*. These devices have the potential to heat and cool interior spaces more efficiently than conventional furnaces and air-conditioners. However, they rely on sophisticated thermodynamic cycles which, although practical in theory, have been difficult to engineer at low cost. ORNL has played a key role in identifying the most promising advanced designs and in supporting R&D with private firms to bring these designs to commercialization.

Because the commercial heat pump market has been highly competitive in the past, with low profit margins, major domestic manufacturers have not devoted extensive resources to improving their products. General Electric and Westinghouse have both sold their HVAC (heating ventilating and air-conditioning) manufacturing businesses, presumably because of low profitability, and Borg-Warner is in the process of spinning off their HVAC division for the same reason. Many heat pump manufacturers are consequently turning to foreign suppliers for their components.

With ORNL support, under Robert C. Devault, several U.S. manufacturers, including Trane Corp., Carrier Corp., and Phillips Engineering are on the verge of marketing *gas-fired absorption heat pumps* with coefficients of performance 40% greater than the best models available to date. These devices will trim $250-$300 per year from the average home's heating and cooling costs.

Electric heat pump efficiencies have recently been climbing by about 2.5% annually, but have still reached only 25% of their theoretical maximum efficiency. Led by Phillip Fairchild, ORNL is now working with several firms to help them develop variable-speed compressors, and to reduce dynamic losses in frosting, defrosting and cycling that have thus far kept advanced designs from reaching their full potential. It is too early to tell how much electric heat pumps can be improved, but the payoff from efficiency improvements already achieved is substantial.

Manufacturers acknowledge that federal R&D support has already advanced heat pump development by two to five years, yielding the prospect of $17 billion in savings when high efficiency heat pumps saturate the space-conditioning market.

Table B.1. Lead-times and Net Savings for Successful DOE-Sponsored Buildings Energy R&D Projects.

	Solid State Ballasts	Low-E Window Films	Residential Absorption Heat Pump	Advanced Electric Heat Pump	High Efficiency Refrigerator Compressor	High Efficiency Refrigerator -Freezer	Heat Pump Water Heater
1. DOE Project Duration	1976-1980	1976-1990[D]	1978-1988	1977-1986	1977-1981	1978-1983	1977-1982
2. Est. 50% Penetration of Sales	1995	2000	2001	1998	1990	1996	1995
3. Years by which DOE advanced commercialization	5 yrs.	5 yrs.	5 yrs.	2 yrs.	2 yrs.	2 yrs.	3 yrs.
4. Cost of Conserved Energy, (CCE)	2¢/kWh	$2/MBtu	$2.50/MBtu	$2.75/MBtu	1¢/kWh	3¢/kWh	3¢/kWh
5. Cost of DOE Project	$3M	$2M	$6.8M	$2M	$1M	$0.8M	$0.7M
6. Net Annual Savings in 1985	$11M	$14M	$0M	$0M	$0.4M	$0.2M	$6.5M
7. Net Annual Savings at Saturation (i.e. 10-15 after 50% penetration)	$5,000M	$3,000M	$2,400M	$2,500M	$1,100M	$850M	$3,000M
8. Cumulative Net Savings (Line 7 x line 3)	$25,000M	$13,000M	$12,000M	$5,000M	$2,200M	$1,700M	$9,000M
9. DOE Project ROI (Return on Investment, =Line 8 ÷ line 5)	8,000: 1	7,000 : 1	1,500 : 1	2,500 : 1	2,000 : 1	2,000 : 1	13,000 : 1

Notes:

A. All dollar savings in energy costs are net of increased costs for purchase of the improved equipment (ballast, window, etc.).

B. Line 4. Cost of Conserved Energy, CCE. We use a real discount rate d = 7%, and the useful life of the product e.g. - 10 years for ballasts, 20 years for windows. The CCE of low-E films, now still a novelty, is currently $4/MBtu, but as the market matures, we estimate that the CCE will drop to $2/MBtu.

C. Line 7. Net Annual Savings at Saturation are in 1985$, uncorrected for: growth in the building stock, changes in real energy costs, or discounted future values. We decided not to account explicitly for these three factors, since all three are uncertain and their combined impact probably small, as shown by the following calculation. To translate savings in 2000 or 2010 to 1985 terms, one multiplies by: exp [(g + e - d)T], with the following annual rates:

$$\left.\begin{array}{l} g = \text{growth rate of building sector (3\%)} \\ e = \text{real price escalation for electricity or fuel (1-2\%)} \\ d = \text{real discount rate (4-7\%)} \end{array}\right\} \quad g + e - d = (-3 \text{ to } +1\%)$$

T = years between 1985 and the est. saturation date, 20 - 25 years.

D. As indicated on line 6, 70m sq.ft. of first generation soft-coat were already installed in 1985, but this soft-coat can be used only between sealed double glazing. Current R&D aims to increase the durability and applicability of sputtered coatings and to produce additional engineering data to better utilize the coatings in sunbelt climates and in commercial buildings.

Source: See case studies.

Table B.2. Summary of Building Conservation Case Studies.

		Solid state ballast[a]	Low-E window films[b]	Residential absorption heat pump	Advanced electric heat pump	High efficiency refrigerator compressor	High efficiency refrigerator/ freezer	Heat pump water heater
1.	Annual energy savings (Btu/unit or kWh/unit)	100 (133)[a] kWh	50,000 Btu	26×10^6 Btu	48×10^6 Btu	162 kWh	280 kWh	2800 kWh
2.	Gross savings/unit (1985 $/yr)	7.5 (10)[a]	0.30	333	404	13	22	224
3.	Life (years)	10	20	20	15	17	17	8
4.	Cost premium ($)	12	1.0	800	1300	15	100	530
5.	Annualized capital[c] ($)	1.70	0.10	71	133	1	10	83
6.	Net savings/unit ($/year)	5.80 (7.75)[a]	0.2	262	271	12	13	141
7.	Simple payback (years)	2	5	2.4	3.2	1.1	4.5	2.4
8.	U.S. stock (millions)	625	18,000 ft^2	17	19	100	100	28
9.	Saturation penetration (%)	95	80	74	67	92	66	75
10.	Saturation units (millions)	600	14,000	13	13	92	66	21
11.	Net annual savings at saturation (1985 $, billions)[d]	3.5 (4.6)[a]	3	2.4	2.5	1.1	0.85	3.0
12.	Cost of DOE project ($, millions)	3	2	6.8	2.0	1.0	0.8	0.7
13.	Commercialization advance (years)	5	5	5	2	2	2	3
14.	Net project savings ($, billions)	15 (25)[a]	13	12	5	2.2	1.7	9.0
15.	DOE project return on investment	8000:1	7000:1	1800:1	2500:1	2200:1	2000:1	13,000:1

[a] The main column of entries describes ballasts which save 25% without feedback dimming control to compensate for daylight and lamp aging. Photocells and dimmers roughly double the surcost and the savings, leaving the cost of con- served energy unchanged. We estimate that 50% of lamps will be undimmed, 50% dimmed, with average savings of 33%. These average predicted values are shown in parentheses.

[b] Unit savings and costs are per square foot of film.

[c]% real discount rate, without tax preferences.

[d] Annual savings are uncorrected for growth in building stock. See note C of Table B.1

Calculation Methodology

An energy-efficient building or appliance that costs more to buy but uses less energy is of no economic interest unless the value of the energy savings exceeds the additional cost of the investment. Here, we explain how we calculate the economics of investment in energy efficiency.

We assume that the consumer borrows the money for the efficient appliance or building and pays off the loan in a series of equal annual payments. We call the portion of his payments that covers the extra cost of greater efficiency an annual "surcost." Dividing the annual surcost by the annual energy savings tells how much the consumer is spending to avoid buying a unit of energy. We call this the cost of conserved energy (CCE), shown in line 5 of Table B.1. Where the CCE is less than the cost of buying energy, conservation makes economic sense. The formula for CCE is:

$$Cost\ of\ Conserved\ Energy\ (CCE) = \frac{annualized\ surcost}{annual\ energy\ savings}\ z\ (1)$$

Example:

The following example shows how the values on Tables B.1 and B.2 yield the cumulative net savings figures on line 9 of Table B.1.

Consider solid-state fluorescent light ballasts, summarized in the first column of Tables B.1 and B.2. Line 1 of Table B.2 tells us that one of these ballasts saves 100 kWh/year. Line 3 tells us that they last ten years and line 4 tells us that they cost $12 more than conventional ballasts. Are they worth the extra cost? To find the answer to this question we must first find the cost of conserved energy. Assume the $12 is borrowed from a bank for ten years at a 7% real interest rate, where "real" means net of inflation. Line 5 then tells us that the "annual surcost" (annual bank payment on the loan) is $1.70. Equation (1) then gives

$$CCE = \frac{Annualized\ surcost}{annual\ energy\ savings} = \frac{\$\ 1.70/yr}{100\ kWh\ /yr} = \frac{1.7\ cents}{kWh}$$

which is rounded on Table B.1, line 5 to 2 cents/kWh. A CCE of 2 cents/kWh is far cheaper than the purchase price of electricity (7.5-10 cents/kWh). Thus, the more efficient ballast is an attractive investment. Half of the CCE entries on line 5 of Table B.1 conserve natural gas instead of electricity. The CCE is expressed in $/MBtu and should be compared with a current gas price of about $6/MBtu.

Converting Energy Savings to Net Savings

The CCE tells us that the ballasts are a good investment. Next we want to calculate our net annual savings, which is simply the energy cost savings minus the annualized surcost.

$$Net\ savings = energy\ cost\ savings - surcost$$

For ballasts, the energy savings are 100 kWh/yr (line 1, Table B.2). Assuming electricity prices of 7.5 cents/kWh, the gross savings are:

$$100k\ Wh/yr \times 7.5\ cents/kWh = \$7.50/yr$$

We already calculated that the annualized surcost for the ballasts is $1.70/yr. Thus

$$Net\ savings = \$7.50/yr - \$1.70/yr = \$5.80/yr \quad (line\ 6, Table\ B.2)$$

By multiplying the net annual savings per unit (line 6, Table B.2) by the number of units in the market at saturation we calculate the net annual savings at saturation (line 8, Table B.1).

Based on discussions with manufacturers, we estimate that federal R&D has advanced commercialization of these technologies by 2 to 5 years. Thus, the cumulative savings consumers will ultimately realize purely as a result of the government's involvement is simply the net annual savings at saturation times the number of years by which that technology was advanced through government R&D (Table B.1. line 8 x line 4 = line 9).

APPENDIX II

Additional Material Submitted for the Record

Congressional Research Service
The Library of Congress

Washington, D.C. 20540

RENEWABLE ENERGY TECHNOLOGY: A REVIEW OF LEGISLATION, RESEARCH, AND TRADE

by

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March 1987

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RENEWABLE ENERGY TECHNOLOGY: A REVIEW OF LEGISLATION, RESEARCH, AND TRADE

INTRODUCTION

This paper reviews the status of wind, photovoltaic and solar thermal technologies. First, it reviews the public laws which created programs at the Department of Energy (DOE) for research and development of these technologies. Second, it describes each technology, its cost trend and its share of domestic and world markets. Third, it examines domestic and foreign spending on solar and other renewable technologies. The conclusion contains some general observations and some suggested issues for congressional consideration.

BACKGROUND

History

The Nation's commitment to solar energy increased significantly during the latter half of the 1970s, spurred by the Arab oil embargo of 1973-74 and subsequent oil price shocks. The energy supply problem focused attention on renewable energy as an alternative to help reduce dependence on foreign oil. This increased commitment was reflected in Federal funding for research and development and enactment of legislation designed to promote the growth of these emerging technologies.

This commitment, however, has been declining in recent years. Federal support for the near-term development, demonstration, and commercialization of solar technologies has been drastically reduced since FY1981, when funding was at its peak. The collapse of oil prices in 1986 further eroded the competitive position of renewable energy technologies relative to conventional energy technologies.

Renewable Energy Technologies

Renewable energy technologies convert undepletable or replenishable energy sources derived directly from solar radiation or indirectly as wind and wood into electricity and heat. Most renewable energy technologies offer some attractive features relative to conventional energy technologies. Some of these advantages include reduced environmental impacts, greater stability in energy prices due to low or zero fuel costs, increased fuel flexibility and diversity, and the potential to add generating capacity in small modules with short lead times. The major disadvantage to some of the technologies is their dependence on intermittent energy sources such as the wind and sun, which subjects them to unpredictable variations in supply. Other disadvantages include high capital costs and low energy density. The latter means that large land areas are needed to collect significant quantities of energy, which can increase installation costs as well as have adverse impacts on the environment.

Wind turbines convert moving air to either mechanical or electrical power via the interaction of the wind and a rotor. Wind turbines may exist singly or in large groups known as "windfarms," which are capable of producing anywhere from several hundred kilowatts to hundreds of megawatts of electricity. Photovoltaic (PV) energy systems use semiconductor technology to convert sunlight directly into electricity. Photovoltaic cells - thin wafers of semiconductor material - are grouped into arrays, oriented toward the sun. The amount of power produced can vary from a few kilowatts (kw) to many megawatts (MW). The modular nature of photovoltaics allows it to serve as an alternative for a wide variety of power sources ranging from batteries in hand-held calculators to utility peak generating plants. Solar thermal systems convert energy from sunlight into space heat, industrial process heat or electricity.

The following discussion deals with the Federal renewable energy program, its goals as promulgated in legislation, the current status of renewable energy programs and the prospects for the future.

FEDERAL RENEWABLE ENERGY PROGRAM AND CONGRESSIONAL INTEREST

Prior to the Arab oil embargo of 1973-74, Federal interest in renewable energy was nominal, with funding for research and development amounting to only a few hundred thousand dollars annually. The energy crisis stimulated the Federal Government to attempt to develop a comprehensive long-term energy program. One result of this attempt was a series of programs whose goal was to provide alternative means of meeting the Nation's energy demands by fostering the development and use of renewable energy resources. These programs provided for Federal support through all phases of the technology development from basic research and development through commercialization. It was within this framework that an ambitious goal was declared for supplying 20 percent of the Nation's energy demand with solar energy (including hydroelectric power) by the year 2000.

The overall strategy of the Federal renewable energy program consisted of: (1) defining the market opportunities for displacing critical nonrenewable resources and providing favorable market environments for renewables, (2) encouraging research and development of renewables for the marketplace, (3) reducing costs so that these technologies would be economically competitive, and (4) promoting rapid commercialization through technology transfer activities. The mechanisms employed to accomplish these goals included joint private and Government demonstration projects, financial incentives such as business and residential tax credits, legislative and regulatory policies, and support for State and regional groups.

Goals for Cost, Installation and Production

Specific cost and technological goals were set for some individual renewable energy programs. The wind energy program goals included:

(1) Reduce wind energy costs to a level competitive with conventional energy by FY1988;

(2) Install 800 MW of wind generating capacity by 1988; and

(3) Accelerate the growth of a commercially viable and competitive industry.[1]

Specific goals for the photovoltaic program were:

(1) Double photovoltaic energy production each year starting in FY1979, resulting in an annual U.S. production of two million peak kilowatts (2,000 MW), and a total cumulative production of four million peak kilowatts (4,000 MW) by 1990;

(2) Reduce the average costs to 15 cents a kilowatt-hour by 1990, and

(3) Promote private purchase of at least 90 percent of all photovoltaic systems produced in the U.S. during FY1990.[2]

The goals for solar thermal technology were not defined as specifically as they were for the other two technologies. One budget request, for FY1980, did include some specific cost and installation goals, but these were not included in later solar legislation.

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[1] These goals appear in the Wind Energy Systems Act, P.L. 96-345.

[2] These goals appear in the Solar Photovoltaic Energy Research, Deveopment and Demonstration Act, P.L. 95-590.

Congressional Interest

Prior to 1974, the Federal program consisted of piecemeal legislation and annual budget allocations. Since then Congress has played an overseer role in the formulation of Federal solar energy policy, traditionally favoring a more comprehensive program than any Administration then in office. Acknowledging the potential of renewable energy as an alternative source of energy, the Ford Administration initiated solar programs, but not to the degree that Congress wanted. The Carter Administration emphasized energy conservation of conventional sources more than the development of alternative supplies. The Reagan Administration has concentrated its efforts on support of long-term, high-risk projects, leaving near-term development efforts to private industry.

In every year since 1974, Congress has appropriated additional funds for the renewable energy program. In addition to appropriations, legislation enacted during this period forms the foundation for current renewable energy policies. Among the major legislation of this period were the following:

P.L. 93-438 -- The Energy Reorganization Act of 1974 consolidated solar and other renewable energy research under the Energy Research and Development Adminstration.

P.L. 93-473 -- The Solar Energy Research, Development, and Demonstration Act of 1974 established a comprehensive solar energy program.

P.L. 93-577 -- The Federal Nonnuclear Energy Research and Development Act of 1974 established a comprehensive national program of research and development for potential alternatives to conventional energy sources.

P.L. 95-590 -- The Solar Photovoltaic Energy Research, Development and Demonstration Act of 1978 established a program for photovoltaic programs to become cost competitive with utility-generated electricity.

P.L. 95-617 -- The Public Utility Regulatory Policies Act (PURPA), part of the National Energy Act, creates a marginal price (avoided cost) payment scheme for power produced by non-utility cogenerators and small (renewable) power producers.

P.L. 95-618 -- The Energy Tax Act of 1978, part of the National Energy Act, authorized residential and business tax credits for use of solar and renewable technologies.

P.L. 95-619 -- The National Energy Conservation and Policy Act, part of the National Energy Act, authorizes financial incentives such as loans, mortgage increases, and grants for use of solar energy technologies.

P.L. 95-620 -- The Powerplant and Industrial Fuel Use Act, part of The National Energy Act, encouraged the use of alternative fuel sources in new industrial and utility plants.

P.L. 96-223 -- The Crude Oil Windfall Profit Tax Act of 1980 increased the tax credits set forth in the Energy Tax Act of 1978.

P.L. 96-294 -- The Energy Security Act of 1980 established the Solar Energy and Energy Conservation Bank which provides federally subsidized loans for solar energy and energy conservation improvements in homes and businesses.

P.L. 96-345 -- The Wind Energy Systems Act of 1980 established specific cost and installation objectives for the wind energy program.

P.L. 97-34 -- The Economic Recovery Tax Act of 1981 shortened the depreciation period for renewable energy technology investments from 18 years to 5 years.

P.L. 98-370 -- The Renewable Energy Industry Development Act established the Committee on Renewable Energy Commerce and Trade (CORECT) and required reports to Congress on the competitive status of the U.S. renewable energy industry.

Current Status and Future Prospects

In view of what some consider a relatively stable energy market as well as huge Federal deficits, the present Administration has substantially reduced funding for solar and other renewable technologies from a peak of $549 million in FY1981 to a request of $71 million for FY1988. These cuts reflect the Administration's policy that direct Federal involvement in research and development projects should be limited to long-term, high-risk technologies. The Federal Government's role in near-term development projects, in the Administration's view, should be as a catalyst to promote private sector research and development of renewable energy technologies. As a result, development, demonstration projects, commercialization programs and subsidies were the targets of stringent cuts. The total elimination of these programs has been blocked by the Congress.

Refocusing Solar Programs

Fifteen years of technological advancement, and a history of conflict over proper funding levels, suggest that a review of program goals and priorities could be timely and useful. The following sections of this paper discuss some of these advancements and summarize the present status of selected solar technologies, providing the groundwork for such a review.

TECHNOLOGY DEVELOPMENT, ECONOMICS AND TRADE

Wind Energy

Technology

The two basic technologies for converting wind to useful energy are horizontal and vertical axis wind turbines.[3] The primary focus of DOE's wind energy R&D program has been the scale-up and testing of progressively larger multi-megawatt (millions of watts, MW) horizontal-axis machines, targeted at electric utility interests. Some major advancements in horizontal axis technology since the late 1970s include: better understanding of wind shear and gravitational loads, subsequent improvements in components such as teetered rotors, flexible towers, gearboxes and blades; and better understanding of relationships among components, which has resulted in lighter weight, lower cost and increased reliability.[4]

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[3] These two machines are distinguished by the direction of the axis (line) about which rotation takes place. In a vertical-axis machine, the blades rotate about an axis which is perpendicular to the wind stream and to the ground. In a horizontal-axis machine, the axis is parallel to the wind stream and to the ground.

[4] U.S. Dept. of Energy. Windpower! Five Year Research Plan, 1985-1990. (DOE/CE-T11) Jan. 1985.

Since the early 1980s, most wind machine installations have taken place in groups, known as windfarms. The vast majority of these windfarms have been installed in California, which has several areas with favorable wind resources. To date, windfarm projects have been dominated by relatively small machines, primarily in the 25 kilowatt (thousands of watts, kw) to 200 kw range. However, from 1981 through 1986, the average size of installed machines grew from 50 kw to about 110 kw. The average power production cost for wind machines has dropped from 30 cents/kwh in 1975 to about 7 cents/kwh today. The present figure comes close to achieving the goal for making wind costs competitive with conventional power by FY1988.[5] Average windfarm installed costs have dropped from $3100/kw in 1980 to about $1600/kw in 1986. Further, the operational performance of windfarms has increased steadily, with the average capacity factor rising from about 7 percent in 1981 to 17 percent today.[6]

California has also presented a unique combination of attractive financial incentives, which included Federal and State tax credits and a relatively high avoided cost payment scheme.[7] The Federal tax credits expired at the end of 1985, and the State tax credits expired at the end of 1986. California still has an avoided cost payment scheme in place, but it has undergone some significant changes over the past few years.[8]

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[5] See discussion of wind energy cost goals on p. 4.

[6] Capacity factor is the proportion of total annual energy output relative to the output which would be achieved if the windfarm operated at its full rated capability for each hour of the year. Several technical factors limit the maximum practical capacity factor to a range from 30 to 45 percent, depending on the available wind resource. One windfarm has recently reached a 42 percent capacity factor. Personal communication with Mike Batham, California Energy Commission, Research and Development Division, Mar. 1987.

[7] Avoided cost payments are required under rules set forth by the Federal Energy Regulatory Commission (FERC) as directed by The Public Utility Regulatory Policies Act (PURPA, P.L. 95-617). FERC stipulates that electric utilities purchase power from windfarms and other small power producers at a price based on the energy and capacity costs that the utility would otherwise incur by generating the power itself or by purchasing it elsewhere.

Market and Trade

The domestic market for windfarms began to flourish in 1981. With Federal and State tax credits in place, the rate of installation grew rapidly through 1985. Total installed wind power exceeded the 800 MW goal that year, and climbed past 1,400 MW in 1986.[9] In 1986, the installation rate dropped for the first time, to about half that of 1985. U.S. manufactured wind machines dominated domestic installations through 1985. Foreign imports were limited to a small percentage of the annual installation rate until 1984, when European machines, primarily from Danish companies, captured one-third of the U.S. market. Since then, foreign imports have garnered an increasing percentage of the domestic market. In 1986, the installation of foreign imports exceeded the installation of domestic machines for the first time: by a two-to-one ratio. This reversal is illustrated in figure 1.

Since 1981, about $2.9 billion of wind equipment has been installed in California windfarms. About $350 million of equipment was installed in 1986.[10] Barring unexpected changes in world energy prices, one expert projects that the annual world market for wind is likely to stay at about the same level

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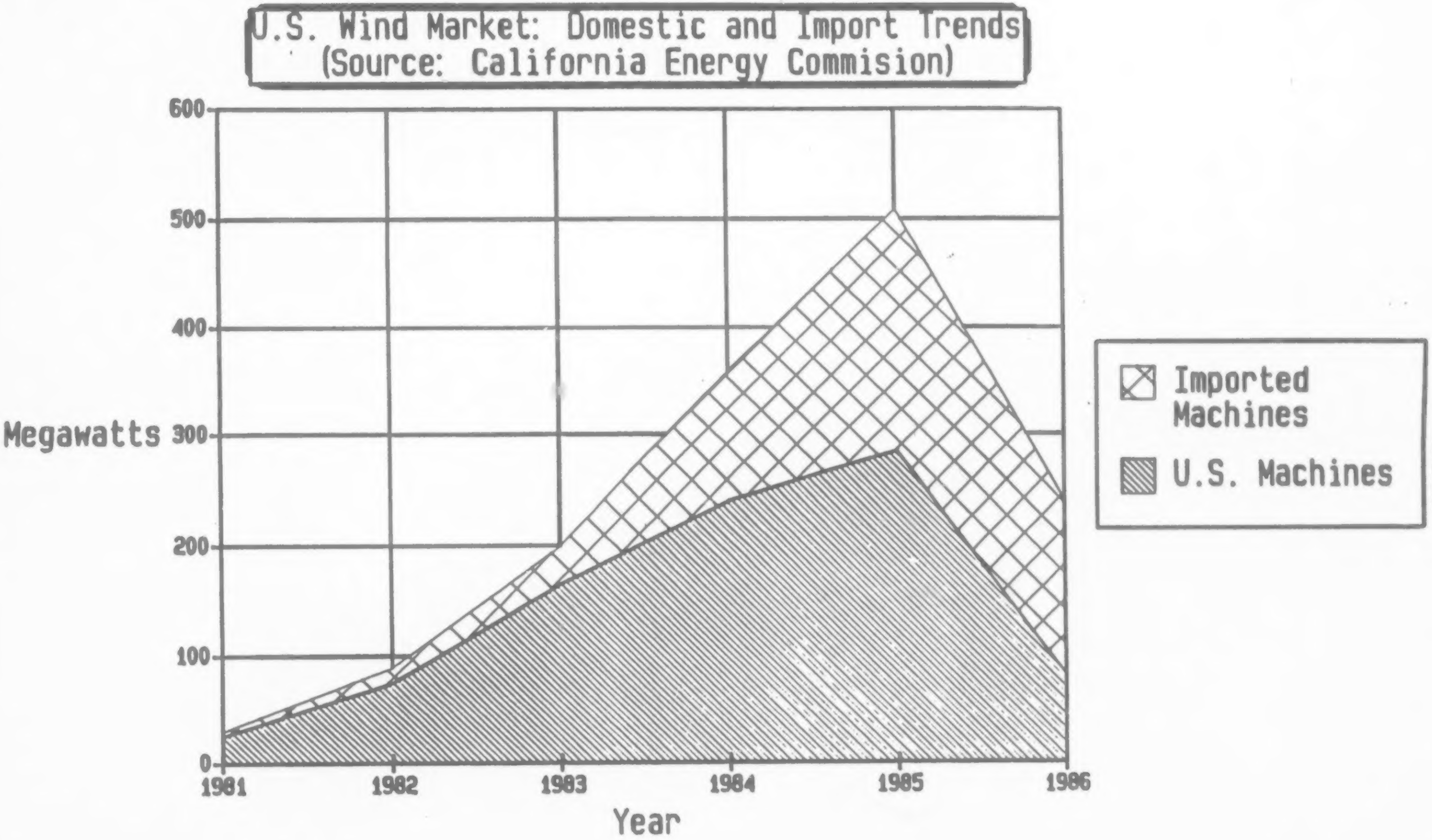
[8] The energy payment has been the major portion of California's avoided cost, but its dependence on oil and natural gas prices has caused it to vary dramatically. In particular, it has fallen off markedly since the oil price drop of early 1986. Some installations have been excepted from this price drop because the owners hold long-term contracts that were established under the Public Utility Commission's (PUC) Standard Offers 2 and 4. These contracts established fixed long-term rates for energy and capacity payments. However, a growing excess of cogeneration capacity caused the PUC to suspend Standard Offers 2 and 4 in early 1986.

[9] See discussion of wind energy installation goals on p. 4.

[10] These dollar figures are rough estimates obtained from the data on installed capacity and installation costs which appear in appendix 1.

Figure 1. Domestic Wind Market



as 1986 for each of the next five years.[11] This would sum to about a $1.8 billion market through 1991.

Several factors may have contributed to the loss of the U.S. domestic wind market to foreign manufacturers. Foremost among these factors may be the perception that foreign machines, especially Danish ones, have shown greater reliability than U.S. manufactured machines. A technical explanation for this perception was offered in testimony presented by Tom Gray of the American Wind Energy Association at a recent House hearing:

> [As a result of Federal R&D] . . . American machines tend to be much lighter and more technically advanced than Danish turbines. In fact, they typically produce three to five times as much electricity per pound of material. However, because of the unexpected [intensity of wind turbulence] . . . they have also been more prone to failure and have required substantially more maintenance.[12]

A second factor which has been suggested is that the Danish wind industry receives more direct government support than the U.S. industry. Although there is a some consensus on this point, it is not documented. A third factor is the small size of U.S. wind firms, which makes it financially difficult, if not impossible, to afford the survey and pursuit of export markets. In any case, one expert says that the result is a world wind market dominated by European technology, with little manufacturing activity in the U.S.[13]

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[11] Personal communication with Tom Jarras. Wind Data Center, Stadia, Inc., Falls Church, Virginia, Mar. 1987.

[12] U.S. Congress. House. Committee on Science and Technology. Subcommittee on Energy Research and Development. Dept. of Energy Authorization for Fiscal Year 1988. Hearing, 100 Cong., 1st Sess., Mar. 11, 1987. (In press) Written testimony. p. 3-4.

[13] Personal communication with Tom Jarras, op. cit.

Photovoltaics (PV)

Technology

A photovoltaic (PV) cell converts light to electric power. PV equipment was first developed to provide power for U.S. space vehicles. In the 1970s, the Federal Government initiated an R&D program to explore the use of PV equipment for commercial power generation. In 1976, PV systems cost about $100,000/kw; they had about a 6 percent conversion efficiency; and manufacturers provided only one year warranties. By 1986, commercial PV costs had been reduced to $5,000/kw, conversion efficiency was up to 13 percent and manufacturers were providing ten year warranties. Depending on the available solar resource, current grid-connected PV power production costs range from about 50 to 75 cents/kwh, still well above the 15 cents/kwh goal set for 1990.[14] In the past three years, the DOE R&D effort has shifted emphasis from a broad range of options to a focus on exploiting the potential of the most promising materials. DOE's PV program includes support for the Electric Power Research Institute (EPRI), which has developed an effort focused on advanced concentrators and amorphous silicon thin films. In general, PV research has aimed at increasing cell efficiency through improvement in design or materials and through optical concentration of sunlight to reduce cell size. This, in turn, reduces the balance of system costs, which are proportional to the cell area. By 1986, laboratory tested PV cells had demonstrated conversion efficiencies ranging from 22 to 28 percent.[15]

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[14] See discussion of PV cost goals on p. 6.

[15] This range includes: silicon 22 percent; two-junction silicon, 26 percent; gallium-arsenide 22 percent; point-contact cell, 28 percent.

Market and Trade

World PV module shipments have grown from about 3 MW in 1980 to over 27 MW in 1986. However, U.S. manufacturers produced only about 7.5 MW of the 1986 total, which falls far short of the 2,000 MW goal set for annual domestic production by 1990.[16] The PV market has been more diverse than the wind market. The applications which have driven the PV market are, in decreasing order of importance: remote power systems, hand-held calculators and grid-connected power systems.[17] The PV market has been, and will likely continue to be, more dispersed globally than wind markets. Manufacturers of PV equipment are also more diverse, including U.S., Japanese, European, Indian and other firms. From 1980 through 1986, about 115 MW of PV equipment was sold worldwide. This amounts to about $0.9 billion in sales.[18] U.S. manufacturers dominated the world PV market from 1980 through 1983. Boosted by sales of PV cells for calculators, Japanese firms steadily increased their market share, becoming the world leader for 1985 and 1986. Companies in Europe, India and other countries have also increased their market share relative to U.S. firms. This reversal of market dominance is depicted in figure 2.

The world market for calculators appears to be nearly saturated now, and the still high installation costs will likely keep the market for grid-connected systems fairly modest. Thus, for the next five years, remote power applications, especially in developing countries, are expected to be the

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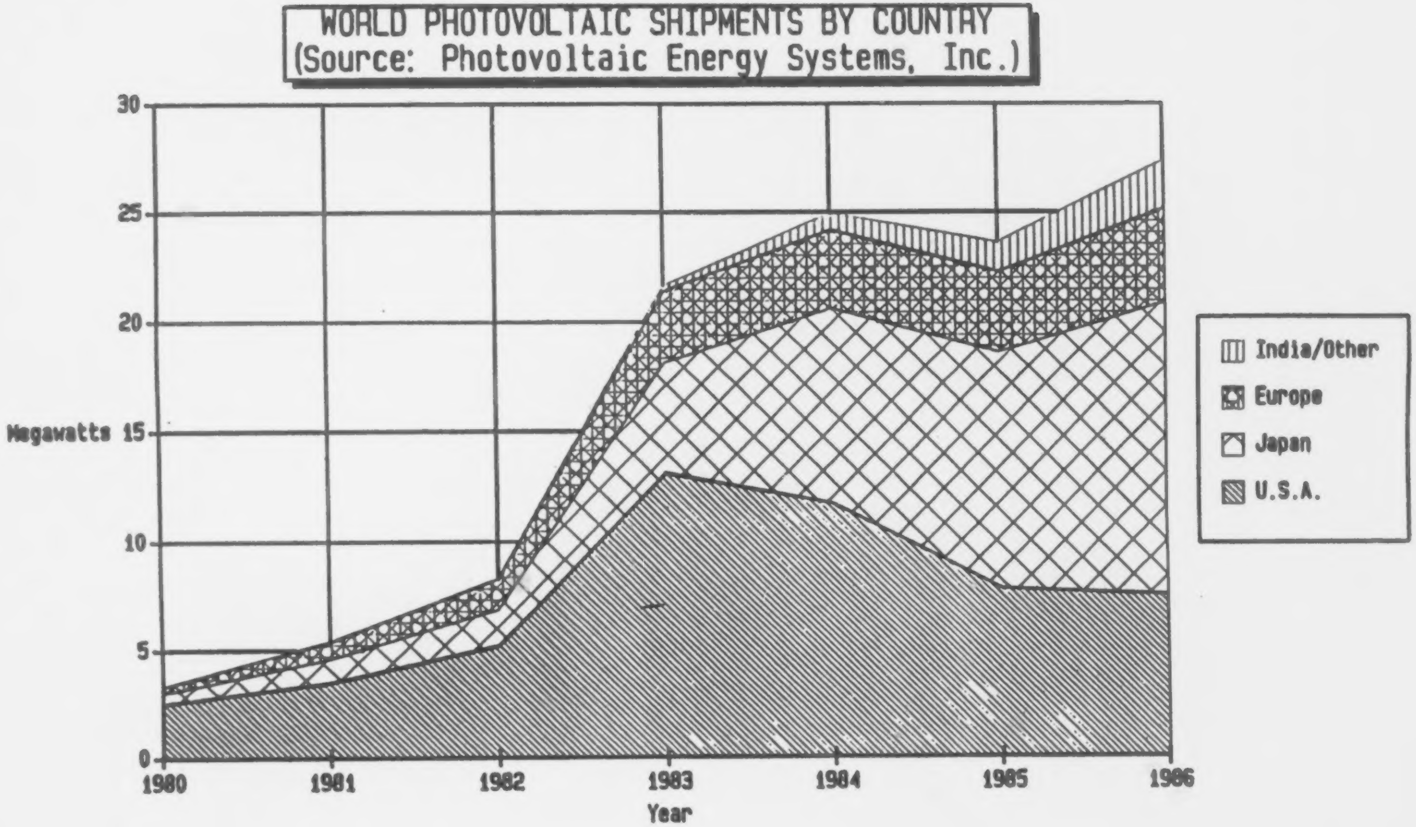
[16] See discussion of PV cell manufacturing goals on p. 4.

[17] Personal communication with Bob Steele, Strategies Unlimited, Mountain View, Ca., Mar. 1987.

[18] This figure is derived from the data on PV module shipments and prices which appear in appendix 2.

Figure 2. World PV Shipments



primary market for PV.[19] Further, the single crystal and concentrator technologies, which dominated shipments in 1983, have been increasingly overcome by shipments of amorphous and polycrystalline technologies.

Strategies Unlimited (SU) estimates that the world PV market will grow to about 150 MW of annual sales by 1990.[20] Its projection suggests that remote power applications, which currently dominate world sales, will continue to do so through 1990.[21] Further, although PV module prices are likely to drop to about $3,000/kw by 1990, system costs are likely to be about $9,000/kw by then.[22] This would place the annual PV market at roughly $1.4 billion.

Solar Thermal

Technology

The primary parts of a solar thermal plant are the concentrator, receiver, storage system and delivery system. An array of mirrors or lenses is used to concentrate solar energy onto a receiver. The receiver can be either a central tower or a distributed system of tubes. The receiver usually contains a fluid which circulates and absorbs the heat. The hot fluid is then used to supply heat for industrial applications or to generate electric power. In some cases, this fluid must be transported through a piping system or stored for later use.

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[19] However, in 1985 and 1986 several U.S. electric utilities began to invested in commercial PV projects, with their combined spending exceeding $40 million. See: Opening the Door for Utility Photovoltaics. EPRI Journal, v.12, Jan. 1987. p. 4-15.

[20] SU is currently reevaluating this projection and expects that it will show a somewhat smaller annual market potential for 1990. However, SU is not yet sure how much smaller this estimate should be.

[21] Because of falling costs for PV components, SU expects that the balance of plant will encompass an increasing proportion of total system costs. Hence, the projection that balance of plant will grow from about 100 percent of PV component cost to about 200 percent of these costs.

[22] It says that utility sales will likely amount to about ten percent of total sales in 1990.

Storage systems utilizing oil/rock, liquid sodium and molten nitrate salt have all been demonstrated in the laboratory.

A solar thermal system can also operate as a cogeneration device. One example is the Solar Total Energy Project in Shenandoah, Georgia. This system produces up to 400 kilowatts of electric power, 1,400 pounds of steam at 350 degrees Fahrenheit and 257 tons of air-conditioning per day.[23] The electricity and steam are used for knitwear pressing and the air-conditioning is used in an adjacent textile mill.[24]

DOE reports that installed cost of a central receiver-electric plant has dropped from about $15,000/kw in 1980 to about $2,900/kw in 1986.[25] The 1986 estimate of the installed cost for a parabolic dish-electric plant is $3,400/kw.[26] For the parabolic trough process heat system, the estimate of installed cost fell from $2300/kw-thermal in 1979 to about $750/kwt in 1986.[27] Technology advancements since the Solar One Project have reduced the costs of heliostats and other components. Solar thermal power presently costs about 13 to 20 cents per kilowatt-hour, which matches conventional costs only in isolated cases. Achieving competitiveness with conventional technologies, says DOE, depends on increasing efficiency and reliability while reducing material and component costs. DOE has set goals of 8 cents per kwh for electric power and $9 per million Btu for industrial process heat.[28]

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[23] This heat production is equivalent to about three megawatts-thermal.

[24] U.S. Dept. of Energy. Solar Thermal Power, (SERI/SP-273-3047), Feb. 1987. 18 p.

[25] U.S. Dept. of Energy. National Solar Thermal Technology Program: Five Year Research and Development Plan, 1986-1990. (DOE/CE-0160) Sept. 1986. The 1980 figure was derived from the Barstow Solar One project; the 1986 figure is based on recent experience and assumes a plant size of 100 MW.

[26] Assumes a five MW plant size.

[27] Assumes a 1.5 MW-thermal plant size.

[28] U.S. Dept of Energy. Solar Thermal Power. (SERI/SP-273-3047) Feb. 1987. 18 p.

Market and Trade

Solar thermal-electric plant installation has been dominated by the Israeli-based Luz Corporation's construction program.[29] For the period from 1984 to 1986, the Luz Corporation reports that it installed about 105 MW of solar thermal power equipment for sales to California electric utilities.[30] Luz estimates that total installed costs for this period averaged about $3,300 per kilowatt. This would place the domestic solar thermal power market at about $350 million. Luz projects annual installation rates of 60 MW per year in 1987 and 1988 and about 90 MW per year for each of the ensuing five years. Using the same value for installed cost, this would amount to an annual domestic market ranging from about $200 million to about $300 million.[31]

RESEARCH AND DEVELOPMENT SPENDING

Since 1973, the Federal Government has spent a total of about $4 billion for R&D on all renewable energy technologies. In particular, it has spent about $450 million for wind, $890 for PV and $810 for solar thermal research and development.[32] At a recent House hearing, several members of the renewable energy industry suggested that spending for renewable energy R&D by most competitor nations has increased significantly while U.S. spending has slacked off.[33] The fall in DOE spending for solar and wind R&D is dramatic, as figure 3 shows. However, it is difficult to assess the claim about foreign

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[29] DOE, National Solar Thermal Technology Program, op. cit.

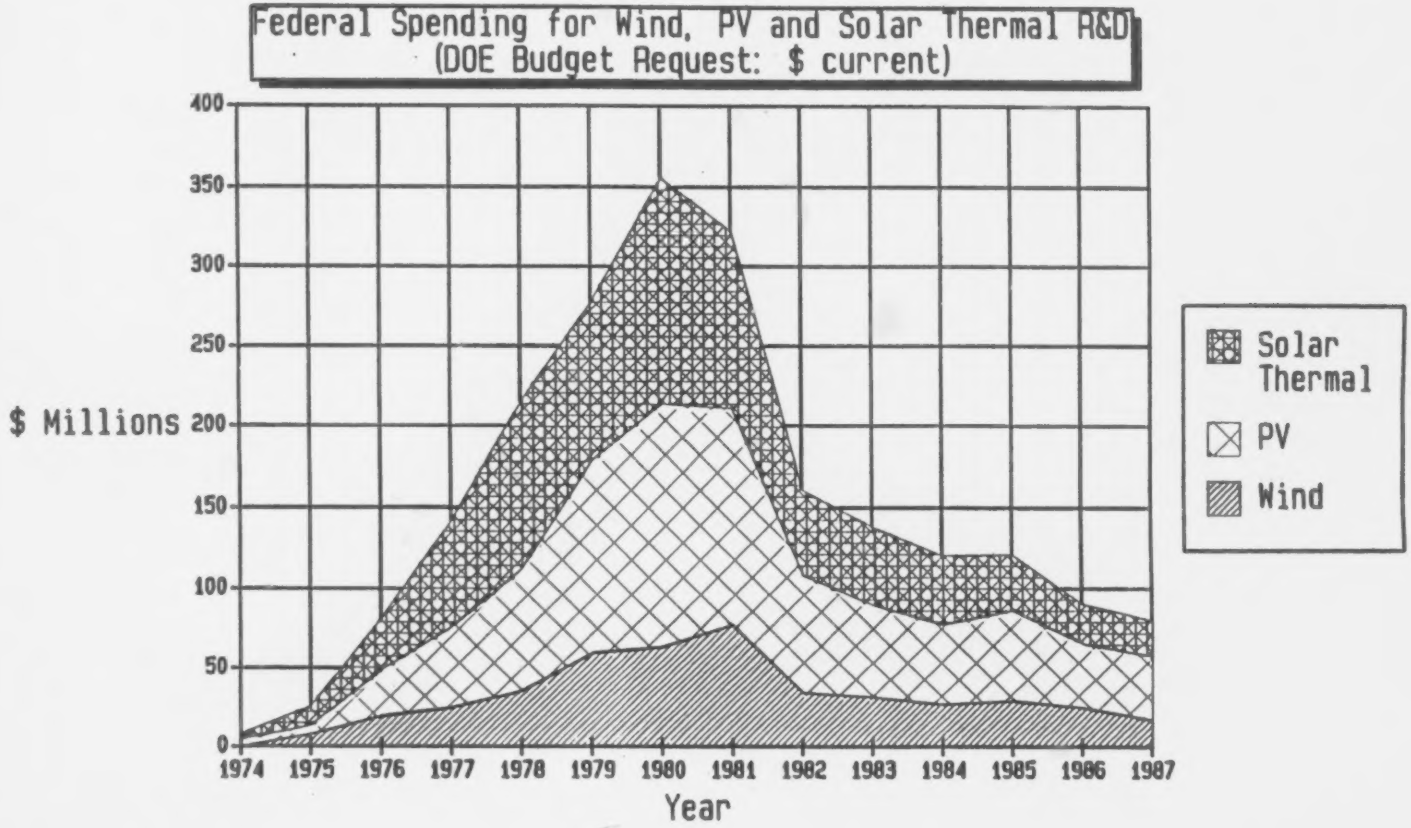
[30] See appendix 3 for annual data.

[31] In 1985, the International Energy Agency projected that by the year 2000, solar thermal technologies could provide as much as 4 quads (quadrillion Btus, British thermal units) of process heat and 28 billion kwh of electric power, the equivalent of about five 1,000 MW powerplants. International Energy Agency. See: IEA Comprehensive Review of Renewable Sources of Energy: Solar Thermal Technology. Sept. 1985. 20 p.

[32] These figures represent current, not constant dollars.

[33] House Subcommittee on Energy Research and Development, op. cit.

Figure 3. Federal R&D Spending



governments' R&D spending because of the lag time in reporting by the International Energy Agency (IEA). The most recent IEA Review of National Programs contains data only through 1984. These data, which appear in appendix 5, do not clearly support this claim. Even greater uncertainty surrounds the claim that foreign governments provide subsidies for manufacturing and exporting, because the IEA does not record these data.

CONCLUSION

Since the early 1980s, a world market for wind, photovoltaics and solar thermal technologies has emerged. In 1986, the annual market stood at about 400 MW and $1 billion. Projections indicate that the world market for these three technologies is likely to grow to about 600 MW and $2 billion per year by 1991. These trends are illustrated in figure 4. In the past three years, U.S. firms have lost their dominance in wind and photovoltaics markets. Also, there has been a massive drop in the domestic residential solar heating market and a rapid growth of foreign solar thermal electric systems in the U.S. utility market. The explanation for the reversal in dominance differs somewhat for each technology. One possible explanation is that U.S. firms have been at a disadvantage because of the high value of the dollar relative to foreign currencies. However, the dollar's value has declined significantly over the past year without a parallel rise in sales of U.S. technology. Another explanation is that some foreign competitors may get more governmental assistance for manufacturing and export than U.S. firms receive. Finally, declining energy prices have greatly reduced the renewable energy market in the United States, causing a number of firms to go out of business.[34]

ISSUES FOR CONGRESSIONAL CONSIDERATION

Further advancements in technology appear to be a necessary condition if U.S. firms are to be able to compete. Some R&D areas which may merit increased attention by the DOE wind program are utility power quality, variable speed operation, comparison of alternative designs, advanced airfoils and stress/fatigue studies. For the PV program, the primary technical problems are improving conversion efficiencies while reducing cell thickness. Both would reduce material and processing costs. Automation and other refinements in manufacturing silicon ribbons could also have important cost impacts. In the solar thermal area, the focus is on reducing the cost of concentrators through the development of membrane and polymer reflectors. Other important advancements may be possible through the development of direct absorption receivers and automation of manufacturing.

However, R&D support alone may not be sufficient to re-establish U.S. firms in a prominent market position. The character of the world market appears to be changing from one dominated by U.S. domestic demand to one driven by a diverse overseas market. In order for U.S. firms to adapt to this change and compete successfully overseas, the Government may have to find innovative ways to support their manufacturing and export activities. The Renewable Energy Industry Development Act (P.L. 98-370) established the interagency Committee on Renewable Energy Commerce and Trade (CORECT), and initiated some

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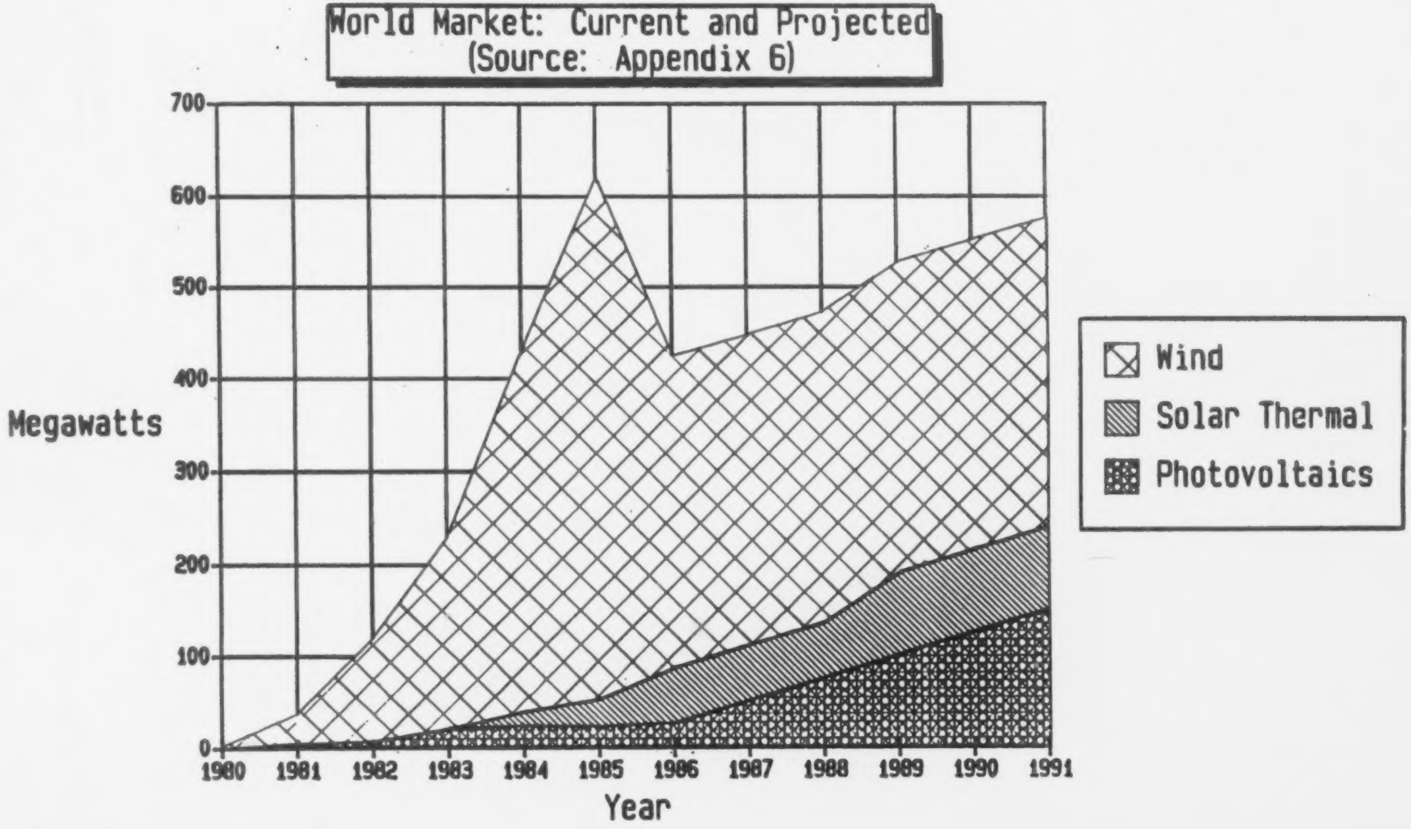
[34] The renewable energy industry feels the impact of declining energy prices primarily through changes in avoided cost payments, which are linked to the price of oil and natural gas.

Figure 4. World Market



export assistance activities for the renewable energy industry. This Act represents an innovative complement to Federal R&D programs, but apparently has not been sufficient to stem the tide of foreign imports and loss of market share overseas. Should the Congress attempt to establish a more aggressive Federal role in export assistance? Are other forms of assistance, such as support for innovative manufacturing technologies also needed? Is it necessary, at this time, to do more than R&D to maintain a domestic renewable energy capability?

Further, the Federal Government lacks a standardized and comprehensive accounting system for renewable energy technology trade. The data that are available are widely dispersed, lack consistent definitions of cost measures, and vary in their definitions of foreign and domestic ownership. Should the Congress initiate a Federal reporting system to track renewable energy technology trade?

Because of its proximity, the domestic electric utility market has been a key one for U.S. firms. It could become even more important for them in the near future. Renewable energy technologies have the potential to address many key utility concerns, such as uncertain demand growth and environmental limitations on conventional powerplant construction. However, the technologies must meet a number of technical, performance and cost requirements before they are widely accepted by utility planners. Further, utilities have only begun to understand the impact of renewable generating sources on system requirements and how to accommodate them in load management and capacity expansion plans.[35]

In particular, utilities are uncertain about how to integrate the variable output from wind and solar power technologies without increasing their operating costs for spinning reserve equipment.[36] Fuel cells and energy storage are two technologies which have demonstrated that they can level the output produced by renewable power technologies. However, these technologies add high installation costs to systems which already have high front-end costs. Nevertheless, the prospect for producing firm power with wind and solar power systems may be attractive enough to warrant R&D on integrated systems as a technological option.[37] Because the cost of such systems would initially be high, they would likely become competitive in the higher-priced remote power market before they could compete for utility markets. The Congress may wish to consider whether a research program for integrated systems have strategic implications for wind and solar equipment exports.

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[35] Meade, William R. and Porter, Kevin L. Utility Decision Making in the 1980s: Implications for Renewable Energy. Renewable Energy Institute. Washington, Sept. 1986. p. 10.

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[36] This problem is discussed in detail. See: U.S. Library of Congress. Congressional Research Service. Wind Energy Development and Utility Capacity Credits: A Review of Research, Implementation and Policy Issues Under the Public Utilities Regulatory Policies Act (PURPA). (by Fred Sissine) CRS Rept. No. 84-101 SPR. June 1984.

[37] The idea of integrating fuel cells with renewable power technologies was discussed in previous congressional testimony. See: U.S. Congress. Senate. Committee on Energy and Natural Resources. Subcommittee on Energy Research and Development. Fuel Cell Research, Development and Commercialization. Hearing, 99th Cong., 2d Sess., Feb. 24, 1986. U.S. Govt. Print. Off. 1986. Testimony of Fred Sissine and Saifur Rahman.

APPENDICES

APPENDIX 1. Wind Data

DOMESTIC WIND ENERGY: INSTALLED CAPACITY
(In megawatts, MW)

	1981	1982	1983	1984	1985	1986	Totals
U.S. Machines	25	75	165	240	285	80	870
Foreign Machines	5	15	35	120	225	160	560
	30	90	200	360	510	240	1430

ESTIMATES OF AVERAGE INSTALLED WIND MACHINE COSTS
($/kilowatt)

1981	1982	1983	1984	1985	1986
3100	2400	2100	1860	1680	1600

Source: Batham, Mike. California Energy Commission. R&D Division. March 1987.

WORLD WIND MARKET: TOTAL SHIPMENTS
(In megawatts, MW)

	1981	1982	1983	1984	1985	1986	Totals
World	34	113	210	393	569	338	1657
U.S.*	23	94	194	375	535	269	1490

*Actually represents North America, although contributions from Canada and Mexico are negligible.

Source: Jarras, Tom. Wind Turbine International Yearbook: 1986-1987. Wind Data Center, Stadia, Inc., Falls Church, Virginia.

APPENDIX 2. Photovoltaics Data

WORLD PHOTOVOLTAIC MODULE SHIPMENTS: CONSUMER AND COMMERCIAL
(In megawatts, MW)

	1980	1981	1982	1983	1984	1985	1986	Totals
U.S.A.	2.50	3.50	5.20	13.10	11.70	7.80	7.47	51.27
Japan	0.50	1.10	1.70	5.00	8.90	10.75	13.40	41.35
Europe	0.30	0.80	1.40	3.30	3.60	3.70	4.30	17.40
India/Other	0.00	0.00	0.10	0.30	0.80	1.40	2.30	4.90
	3.30	5.40	8.40	21.70	25.00	23.65	27.47	114.92

Source: Photovoltaic Energy Systems. Casanova, Virginia. March 1987.

WORLD PHOTOVOLTAIC CELL SHIPMENTS: COMMERCIAL ONLY
(In megawatts, MW)

	1983	1984	1985	1986	Totals
U.S.A.	9.30	8.40	7.50	7.20	32.40
Japan	2.80	5.30	6.40	8.20	22.70
Europe	2.20	2.90	3.70	3.40	12.20
India/Other	0.30	0.80	1.80	3.20	6.10
	14.60	17.40	19.40	22.00	73.40

PV MODULE PRICES
($/kw)

1980-1982	1983	1984	1985	1986
$10,000	8,000	8,000	7,000	6,000

Source: Strategies Unlimited. Mountain View, California. March 1987.

APPENDIX 3. Solar Thermal Data

SOLAR THERMAL-ELECTRIC DOMESTIC UTILITY INSTALLATIONS
(In megawatts, MW)

	1984	1985	1986
Megawatts	15	30	60
Total Installed Costs/kw	$ 3300	3300	3300

Source: Cliff Webb, Luz Engineering, Los Angeles, CA. (213) 208-7444.

DOMESTIC SOLAR SPACE & WATER HEATING EQUIPMENT SALES
($ millions)

1985	1986
$ 900	$ 300

Source: House Subcommittee on Energy Research and Development, op. cit., Testimony of Scott Sklar.

APPENDIX 4. Federal R&D Spending Data

U.S. R&D SPENDING: SELECTED RENEWABLE ENERGY TECHNOLOGIES
($ millions, current)

	WIND	PV	SOLAR THERMAL	ANNUAL TOTALS
1974	$ 0.4	3.5	4.4	8.3
1975	7.9	5.0	13.2	26.1
1976	19.3	28.9	33.3	81.5
1977	24.6	50.9	67.1	142.6
1978	35.3	76.2	104.1	215.6
1979	59.6	118.5	100.0	278.1
1980	63.4	150.0	143.2	356.6
1981	77.5	133.2	112.0	322.7
1982	34.4	74.0	52.9	161.3
1983	31.4	58.0	49.5	138.9
1984	26.5	50.4	43.8	120.7
1985	29.1	57.0	35.5	121.6
1986	24.8	40.3	25.5	90.6
1987	16.7	40.4	22.9	80.0
TOTALS	450.9	886.3	807.4	2144.6

Source: Department of Energy.

APPENDIX 5. Foreign R&D Spending Data

Table A
IEA Government RD&D Budgets for Renewables in 1984 United States Dollars (1) (millions)

	1977	1978	1979	1980	1981	1982	1983	1984
Australia	6.0	-	9.0	12.6	15.5	-	12.2	5.1
Austria	3.0	3.9	4.5	5.5	4.2	4.0	4.4	3.3
Belgium	1.1	1.4	3.6	6.1	9.5	4.7	6.8	6.5
Canada	13.7	32.7	36.4	37.7	58.5	48.9	53.6	54.3
Denmark	2.3	4.5	8.5	4.0	2.6	2.6	2.4	2.4
Germany	13.7	23.2	50.7	53.2	55.9	84.8	40.8	39.5
Greece	.4	.6	1.7	6.7	8.3	2.2	2.1	3.0
Ireland	.3	.6	1.0	1.2	3.8	3.2	1.7	.7
Italy	3.7	8.0	7.8	14.9	28.2	13.9	24.2	68.8
Japan	23.1	28.8	37.1	90.4	88.8	92.4	83.8	77.6
Netherlands	9.6	10.9	12.6	14.1	16.9	16.3	19.0	25.6
New Zealand	1.5	2.6	2.3	3.2	3.2	2.4	2.7	1.6
Norway	.2	2.2	4.7	4.3	3.5	2.7	2.9	2.4
Portugal	-	-	-	.6	.6	.7	1.1	1.5
Spain	4.7	3.1	7.5	18.7	13.7	13.7	29.3	41.2
Sweden	10.2	19.6	38.8	33.0	42.0	40.2	29.5	20.1
Switzerland	3.1	4.9	7.4	7.5	7.9	6.6	7.6	8.1
Turkey	-	-	-	.4	.3	.3	.5	.5
United Kingdom	4.0	11.5	20.1	17.9	25.8	19.4	15.2	20.2
United States	381.8	572.4	775.4	847.3	761.2	365.5	275.3	229.0
Total	482.6	731.0	1029.3	1179.2	1150.4	724.6	615.1	611.3

---

(1) For the calculation of values in 1984 U.S. dollars, the same procedure has been used as for Table 1C.

Source: Energy Research, Development and Demonstration in IEA Countries (Draft) 1984 Review of National Programmes.

APPENDIX 6. World Market Data

CURRENT WORLD MARKET FOR SELECTED RENEWABLE ENERGY TECHNOLOGIES
(In megawatts, MW)

	1980	1981	1982	1983	1984	1985	1986	Totals
WIND	3.3	34.0	113.0	210.0	393.0	569.0	338.0	1657.0
PHOTOVOLTAICS	--	5.4	8.4	21.7	25.0	23.7	27.5	114.9
SOLAR THERMAL	--	--	--	--	15.0	30.0	60.0	105.0
ANNUAL TOTALS	3.3	35.4	98.4	221.7	400.0	563.7	327.5	1649.9

Sources: Wind Data Center, Photovoltaic Energy Systems, and Luz Engineering.

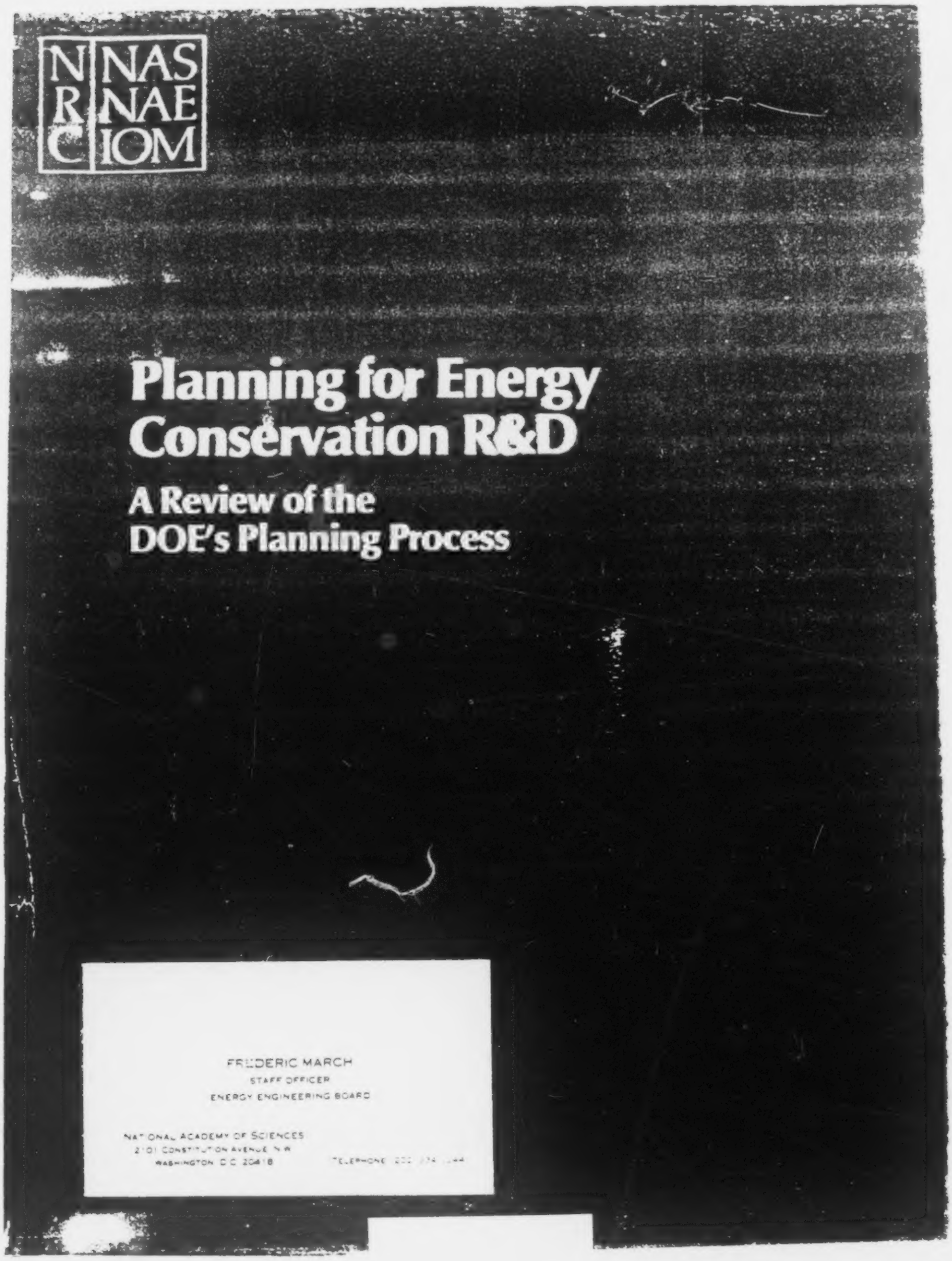
PROJECTED ANNUAL WORLD MARKET FOR SELECTED RENEWABLE ENERGY TECHNOLOGIES
(In megawatts, MW)

	1986	1991
WIND	338.0	338.0
PHOTOVOLTAICS	27.5	150.0
SOLAR THERMAL	60.0	90.0
TOTALS	425.5	578.0

PROJECTED ANNUAL WORLD MARKET FOR SELECTED RENEWABLE ENERGY TECHNOLOGIES
($ billions, current)

	1986	1991
WIND	$ 0.54	0.54
PHOTOVOLTAICS	0.33	1.35
SOLAR THERMAL	0.20	0.30
TOTALS	1.07	2.19

Sources: Wind Data Center, Photovoltaic Energy Systems, and Luz Engineering.



NRC NAS NAE IOM

Planning for Energy Conservation R&D

A Review of the DOE's Planning Process

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Planning for Energy Conservation R&D

A Review of the DOE's Planning Process

A Report Prepared by the
Committee on Energy Conservation Research
Energy Engineering Board
Commission on Engineering and Technical Systems
National Research Council

NATIONAL ACADEMY PRESS
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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

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PREFACE

This report responds to a request from the U.S. Department of Energy (DOE) to the National Academy of Sciences for a critique of DOE's planning process for federally sponsored research and development (R&D) in the area of energy conservation. In response, the National Academy of Sciences created a Committee on Energy Conservation Research under the National Research Council's Energy Engineering Board.

Specifically, the committee was asked to:

- Review the long-term, energy-related planning context within which DOE's Office of Conservation operates and examine the goals and objectives of each of the office's major programs.
- Critique the Office of Conservation's multi-year planning process, focusing in particular on the use of outside expertise (extent and balance) and the methods used in setting priorities for proposed projects.
- Examine and critique current (and implicitly cumulative) program emphasis, balance, and diversity in relation to long-term technological needs and opportunities for energy conservation.
- Identify potential new areas of research and, if warranted, examine in depth a few selected areas and suggest changes in priorities.

To carry out its tasks, the committee organized a two-day "roundtable" (see Appendix A). The roundtable explored the understanding and the uses being made of DOE's multi-year plan (MYP) by persons outside the department, the role of the national laboratories in the planning process, and the approaches taken to multi-year planning for energy conservation in several other countries.

Of the four tasks above, the committee has chosen to emphasize long-term planning and the multi-year planning process, taking into account the economic, technological, and institutional uncertainties, together with the complex framework of planning guidance provided by the policy context. In emphasizing these tasks, the intent of the committee has been to make recommendations that are realistic and practical. Three of this report's four chapters are devoted to these two tasks.

The latter two tasks receive somewhat lesser emphasis. To some extent, the choice of research projects and their overall balance is a function of technical opportunity rather than the satisfaction of preconceived goals. The committee is more concerned with the process that generates a particular portfolio than with the portfolio itself. While some additional research opportunities have been identified, no new or revised plan for the Office of Conservation has been developed. Nor has the committee sought to substitute its own judgment or preferences for those of the various technical specialists within and outside the Office of Conservation who have contributed to the multi-year plan.

Within the Office of Conservation, the multi-year plan for fiscal year 1986 was the first of its kind. The plans for fiscal years 1987 and 1988 represent an attempt to benefit from earlier experience. This report focuses on the multi-year plan for 1987, as the most current version at the time of the committee's work. In his letter commissioning this study, dated July 10, 1984, Alan J. Streb, deputy assistant secretary for conservation, stressed the following:

> In particular, we would like the Academy to build on existing work with the Office of Conservation, update some of its previous reviews, expand its areas of familiarity to encompass other parts of our program, and produce an overall consolidated report of its findings.

The very fact a multi-year plan exists, together with a process for creating it, is meritorious. Planning for R&D is a very difficult undertaking. It requires a carefully orchestrated team effort within the Office of Conservation and the coordination of inputs from many different outside sources. This has clearly been an important and successful undertaking.

During the course of the study the committee interacted with staff members at a two-day roundtable on December 4-5, 1985. As a result of the roundtable and follow-up discussions, the Office of Conservation has had the opportunity to implement some of the committee's recommendations for the fiscal year 1988 multi-year plan. Many of the recommendations will require more time to implement, and some will require institutional changes beyond the ability of the Office of Conservation to implement alone.

While this report is specifically addressed to DOE, the committee hopes it will be of interest to all energy policymakers and R&D planners, people in private research organizations and university laboratories, and to nonspecialists interested in energy R&D and public policy.

The committee would like to thank Dennis Miller, executive director of the Energy Engineering Board, for organizing and supervising this effort, and Frederic March, study director, who worked with the committee in preparing the report. The committee also thanks Rosena Ricks for her role in organizing the roundtable and other meetings and in helping to prepare this report.

WILLIAM R. GOULD, Chairman
ANTHONY J. FINIZZA, Co-Chairman
Committee on Energy
Conservation Research

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EXECUTIVE SUMMARY

The major conclusions of this report are:

- The institutional, economic, and technical contexts for multi-year planning create problems, which generally require higher-level policy action and are beyond the direct control of the Office of Conservation. Recommendations on how these contexts can nevertheless be influenced to some degree by the multi-year plan (MYP) are provided.
- The framework for planning encompasses a collection of goals, objectives, strategies, and criteria, which are drawn from national science and energy policy, and is presented in the MYP as guidance for the planning process. This guidance, however, is unfocused and provides an inadequate grounding for the development of planning methodologies. Recommendations on how to provide a focused framework of goals, objectives, and strategies for research and development (R&D) planning are provided.
- The planning process itself is basically sound, but could be improved. For example, a full-time planning director is needed to improve the overall management and coordination of the program and to carry out the full range of recommendations contained in this report. The process of planning can be improved by taking retrospective program reviews and technology assessments into account in a more formal manner than now occurs. Strategic planning methodologies should be studied for possible adoption for the multi-year planning process. In addition, planning for technology transfer from an early stage should be improved and applied to all projects.
- Improved portfolio balance and diversity can be achieved by setting portfolio targets grounded on criteria consistent with the framework of guidance, and then planning toward these targets using improved methodologies. In the future, the portfolio should include social science research to understand

better how energy users behave as well as research aimed at the energy facilities of the federal government, the largest single consumer of energy in the nation.

THE CONTEXT FOR MULTI-YEAR PLANNING

In promulgating the MYP, the Office of Conservation works within a context characterized by economic, technical, and institutional uncertainties. While the first two can be dealt with by using appropriate analytical methods, resulting problems from institutional uncertainty, such as budgetary commitments and mandated programs not meeting program criteria, will require action by Congress and the administration.

Economic and Technical Uncertainty

The price of crude oil in the international marketplace has, experienced rapid decline and is now less than $15 per barrel. The savings are being passed on to consumers, thereby reducing the short-term economic incentive for private sector investments in energy conserving technologies and the incentives for domestic fossil energy development. In the long term the price of oil may well rise again in response to shifts in supply, demand, and price relationships. Meanwhile, lower oil prices stimulate higher demand, which increases the rate of depletion of a finite resource. Thus, research related to energy conservation merits continued and increased budgetary support, particularly when oil prices are low and oil consumption is accelerated by increased demand.

These considerations suggest that the Office of Conservation should more effectively implement the strategic planning philosophy stated in its MYP:

> . . . planning must embrace a fairly broad and diverse set of energy futures. One must envision both optimistic and pessimistic outcomes for each fuel, for each time horizon, and/or each objective (DOE, 1985, p. 26).

This philosophy should lead to a portfolio that will help the nation prepare for several possible economic outcomes (i.e., various scenarios of energy supply, demand, and price). However, the development of planning methodologies grounded on a strategic planning philosophy requires careful study and consideration of the resources available for planning. Such methodologies should be designed to enhance the confidence of the planners in selecting and prioritizing projects.

Budgetary Uncertainty

The Office of Conservation's budget authority has declined from $412 million in 1981 to an administration request for fiscal year (FY) 1986 of $169 million (ERAB, 1985e). This decline results mostly from administration policy to phase out support for large, costly demonstration projects. Additional budget erosion can be attributed to policies related to reducing the overall budget deficit, including the Gramm-Rudman-Hollings law. This reduction in support for energy conservation R&D has had an adverse affect on research centers, particularly private sector contractors who may be cost sharing and who have made capital investments on the assumption of multi-year federal program commitments.

Steps should be taken to stabilize the budgetary and contractual commitments to long-term research. This should include a study of the multi-year budget practices for R&D in other countries, particularly West Germany and Canada, which can provide useful models for the federal government to consider. By stabilizing its commitments, the Office of Conservation will help to ensure continuity of important long-term R&D programs and to maintain the confidence of the private sector in cost-sharing programs for its own R&D investments.

Mandated Programs

Congress has traditionally mandated specific research programs into law, especially energy-related research. The multi-year planning process has no control over the choice or scope of these programs. In energy conservation, examples include the electric and hybrid vehicle research, multi-fuel engines for advanced automotive propulsion, and the Stirling engine.

Congress should mandate specific R&D programs for the Office of Conservation only within the context of the MYP. Improving the quality of planning and the presentation of the MYP may increase congressional understanding of the overall program. Should Congress continue to choose to mandate specific programs, it may be informed by and made compatible with the criteria of the office within the framework of the multi-year planning process. In addition, the committee recommends that add-on funding be provided for mandated programs in order not to compete for funds with the discretionary programs.

THE FRAMEWORK OF GUIDANCE FOR MULTI-YEAR PLANNING

The multi-year planning process is grounded on a hierarchy of planning guidance at four levels: national science and technology policy, Department of Energy overall purposes, Office of Conservation planning guidance, and detailed guidance by each of the office's four major programs (transportation, building and community systems, industry, and energy utilization). Moreover, at each level, sublevels of guidance, such as goals, missions, objectives, strategies, and criteria, are introduced. (These are compiled from the MYP for FY 1987 in Appendix C).

This framework of guidance has a number of problems. These include the excessive generality of guidance statements, lack of reference to quantifiable or concrete criteria, confusion of levels, overlapping of instructions, lack of adequate logical connections between various elements of the guidance, and too many levels of guidance. In addition, the hierarchy of guidance reflects a confusion in the meaning of the terms "objectives," "strategies," and "methodologies."

The hierarchy of planning guidance should be reformulated at the levels of the Office of Conservation and its four constituent programs to correct the above deficiencies. In providing guidance to any planning process, "objectives" should be concrete statements of end-points whose achievement can be measured. "Strategies" should be specific actions that move toward stated objectives. "Methodologies" should be analytical frameworks based on explicit criteria for assessing cause and effect relationships of relevance to planners. Moreover, statements of mission, goals, and objectives should be quantifiable in principle.

Chapter 2 suggests how the guidance statements can accordingly be reformulated and consolidated into fewer levels. It is expected that the Office of Conservation will respond with its own critique and fine tuning of these suggestions.

THE MULTI-YEAR PLANNING PROCESS

There are a number of weaknesses in the planning process which for the most part can be strengthened by the Office of Conservation.

Need for a Planning Director

Many of the planning problems indicated can be attributed to newness and the lack of institutionalization of the process. The actual writing of the MYP is only the final step in a process involving a complex set of considerations on a continual basis. This includes the creation of methodologies, program analysis, technology assessment, and the management of outside inputs. Furthermore, the MYP plan is produced by an ad-hoc team headed by a special assistant to the assistant secretary. Its members have other duties and commitments as well.

Therefore, DOE should create a planning director, reporting to the deputy assistant secretary for conservation, with appropriate staff. The director should be designated to manage the multi-year planning process on a full-time basis. This will strengthen the overall management and coordination of the process by focusing the time of the program managers on actual portfolio decision making, with planning support services being provided by the new position.

Management Effectiveness

The overall management process for the MYP is sound but could be improved in a number of ways. For example, interaction with the private sector should be increased, particularly to achieve a greater degree of cost sharing. Project decision milestones should be presented over the five-year planning horizon. In particular, projects should be systematically analyzed with explicit criteria showing reasons for continuation or phaseout. Projects representing new generic research should be phased in, while those evolving into a product development stage should be phased out. The time to initiate a new project is currently excessive and procedures should be introduced to shorten the period to under one year. Finally, the national laboratories can play a larger role in the planning process.

By taking these measures, the Office of Conservation will increase its overall management control and effectiveness in multi-year planning. The office should seek to provide incentives to its managers to accomplish these measures.

Strategic Information Inputs

The MYP does not adequately reflect or benefit from retrospective program reviews or technology assessments. While these are both referred to and performed in the plan to some degree, their use in making planning decisions is not evident. In addition, the activities of the Basic Energy Sciences Program of the Department of Energy (DOE) have relevance to the Office of Conservation's programs, but there is no effective communication between these two DOE divisions.

DOE should improve the process for generating retrospective program reviews and technology assessments. In addition, the MYP should show explicitly how these assessments are used to initiate, continue, or terminate projects. The Basic Energy Sciences Program should be used as an important source of technical data bearing on technology assessments and research opportunities.

By implementing these measures, the Office of Conservation will have increased confidence in the outcome of planning decisions and will be able to communicate this to higher policy levels within and outside of DOE.

Technology Transfer and Cost Sharing Strategies

The MYP does not adequately reflect planning for technology transfer. The goal of technology transfer can certainly be forwarded by a policy that encourages the private sector to share the cost of research. However, significant cost sharing can be realistically achieved largely for short-term, low-risk projects. Therefore, a policy of encouraging increased cost sharing may have the effect of eroding the Office of Conservation's commitment to long-term, high-risk research projects.

To avoid this, the level of cost sharing for this segment of the portfolio should be only 0 to 10 percent.

The Office of Conservation should develop various technology transfer strategies and articulate them in the MYP for each of its four programs (transportation, buildings, industry, and systems). Similarly, cost-sharing strategies tailored to the realities of low-risk and higher-risk projects should be developed. These strategies should identify early partners in the private sector for application of the research results. By improving the planning for technology transfer, the Office of Conservation will accelerate the adoption of new technologies, materials, and processes.

Planning Methodologies

The planning methodologies used by the Office of Conservation do not appear to be directly linked to the articulated framework of planning guidance presented in the MYP as summarized in Appendix C and reformulated in Chapter 2. Also, while the multi-year planning process has the classic attributes of a strategic planning process, the methodologies used by the office do not reflect this. Methods are largely based on the professional experience and intuition of the program managers.

While there is no satisfactory substitute for experience and knowledge, more formal methodologies should be explored. They should be based on strategic planning concepts and formally linked to the hierarchy of planning guidance. Such techniques have been applied elsewhere (Stokey and Zeckhouser, 1978; Nesbitt et al., 1985, 1981 and Bender et al., 1981), and merit consideration.

The Office of Conservation should study alternative approaches to strategic planning and its application to the needs of its programs. This research should ensure the office's ability to respond to a hierarchy of guidance in a more orderly and demonstrable manner, to map out decision trees showing the implications of alternative decision scenarios taking future uncertainty into account, and to communicate better the results of planning. By implementing this approach, the Office of Conservation will improve the relationship between its research portfolio and long-term national needs.

THE PORTFOLIO

The Office of Conservation's portfolio contains about 150 projects, representing a vast spectrum of technical and end-use diversity. While the committee does not attempt to replan or prioritize these projects, some limited additions to the portfolio are suggested that would help improve its overall balance and diversity as well as its relationship to the hierarchy of guidance.

In general, portfolio planning should proceed from an explicit set of targets that are clearly grounded on the hierarchy of guidance to a portfolio scenario that can be measured against concrete criteria.

Adjustments can then be made as required by using more advanced strategic planning methods that address a multi-objective decision framework. The result will be a more appropriately diverse and balanced portfolio that will better satisfy the multiple goals and objectives of the Office of Conservation.

The portfolio should also be divided according to time-to-commercialization as follows: short (1-3 years), medium (3-10 years), and long (more than 10 years) term. The percentage in each category will depend on each program. This division should be made as part of the decision process and not be a circumstantial result of other decisions. Cost-sharing targets could then be established in response to investment criteria of the private sector.

The portfolio of projects in the MYP should be expanded to include research on energy conservation in government facilities. The federal government is the largest single owner of energy-consuming facilities in the country. Research in this area would be largely short term and low risk. It offers the Office of Conservation a major opportunity for cost sharing with other federal agencies.

Finally, the portfolio should be expanded to include social science research in order to increase the understanding of consumer behavior relevant to energy use. Such research can help show how relatively small investments can produce major reductions in energy use by millions of individual consumers.

1.

THE CONTEXT FOR MULTI-YEAR PLANNING

OVERVIEW

This chapter examines the wider context for multi-year planning, and focuses on issues that are for the most part not under the direct control of the planner but must be understood to plan effectively.

The first section describes the organizational and budgetary contexts for the Office of Conservation. The conservation program is only a small portion of the overall Department of Energy (DOE) budget, and it has declined since 1981. Nevertheless it remains a significant program, and merits the attention of a multi-year planning process.

The second section describes the contents of the multi-year planning document, providing a general reference for the critique which follows.

The third section explores issues related to planning under uncertainty. Economic and technological uncertainties can be dealt with through strategic planning approaches, but the planner has few tools to deal with institutional uncertainties such as the budget process, the lack of multi-year funding as counterpart to multi-year planning, and changes in policy from one administration to another or in response to changes in senior executive personnel. These issues are not new, and are covered in much greater detail in other studies cited herein. The committee simply wants to show its awareness of key contextual problems in order to outline the limits confronted by the planners and to suggest that policymakers consider alternative solutions.

The fourth section discusses the uses made of the multi-year plan (MYP) by persons outside DOE that go considerably beyond the original intent that it be an internal working tool for the Office of Conservation. Its readership has come to include members of congressional committees and their staffs. It is a credit to the MYP that it has become a source of information considered vital to higher-level policymakers. However, not taking such readership into account in the design of the MYP results in poor understanding of key issues and fails to elicit the full measure of support for the programs which the committee finds have merit.

The fifth section focuses on one aspect of congressional decision making that can be positively and legitimately influenced by the plan, namely, the mandating of specific research and development (R&D) programs by statute. The committee recommends that the plan be more oriented to the policy-level reader partly to help reduce the divergence in criteria between mandated programs, and programs meeting the MYP criteria.

The sixth section turns to a more difficult but critical problem for the R&D community, namely, the issue of multi-year funding as a counterpart to multi-year planning. To articulate possible options the committee, at its roundtable, explored multi-year funding practices for analogous programs in several other countries (see Appendix A). Clearly, a resolution of this issue is beyond the scope of the Office of Conservation which represents only a small segment of the overall R&D community affected by current federal practices. However, the committee considers this issue to be of great importance to energy conservation R&D.

The seventh and final section focuses on the role of the Office of Conservation in view of its unique R&D portfolio and the potentially high positive impacts of successful projects. It is argued that support for energy conservation R&D should be increased at a time when oil prices are very low to provide the future technological base when energy prices in the long term escalate. In this way an investment in conservation R&D becomes a form of insurance against future price escalation (NRC, 1986a).

In examining the context for multi-year planning of energy conservation R&D the committee drew on a wide-ranging body of literature, much of which is cited within this report. Appendix B cites what the committee considered to be relevant background literature.

ORGANIZATIONAL PERSPECTIVE

Several illustrations are given to depict relevant organizational information pertaining to DOE. Figure 1-1 shows the organization and 1985 budget figures for the major offices in the Department of Energy (DOE). Figure 1-2 shows the organization of DOE's Office of Conservation and its four constituent programs: transportation, industry, buildings, and energy utilization. Table 1-1 contains the budget figures for the Office of Conservation's programs since 1981. Table 1-2 summarizes the legislative authority for most of the Office of Conservation's activities.

The electric energy systems and the energy storage programs, previously part of energy systems research, have recently been moved to the Office of Solar Energy, leaving the Energy Conversion and Utilization (ECUT) program in the Office of Conservation.

The Office of Conservation has experienced a major budget decline since 1981. Although it is a very small portion of the overall DOE budget, the current budget for R&D in energy conservation remains

NOTE: Dollar amounts are for FY 1985

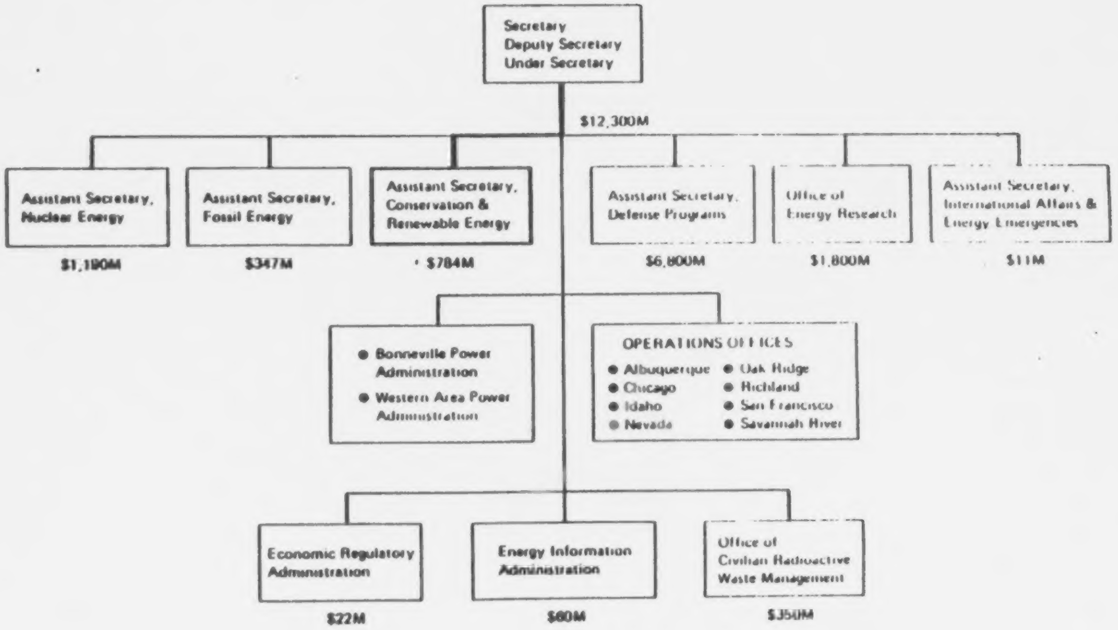
Secretary
Deputy Secretary
Under Secretary
$12,300M
Assistant Secretary, Nuclear Energy
$1,190M
Assistant Secretary, Fossil Energy
$347M
Assistant Secretary, Conservation & Renewable Energy
$784M
Assistant Secretary, Defense Programs
$6,800M
Office of Energy Research
$1,800M
Assistant Secretary, International Affairs & Energy Emergencies
$11M
Bonneville Power Administration
Western Area Power Administration
OPERATIONS OFFICES
Albuquerque
Chicago
Idaho
Nevada
Oak Ridge
Richland
San Francisco
Savannah River
Economic Regulatory Administration
$22M
Energy Information Administration
$60M
Office of Civilian Radioactive Waste Management
$350M

FIGURE 1-1 DOE Organization

SOURCE: Office of Conservation
NOTE: Dollar amounts are for FY 1985

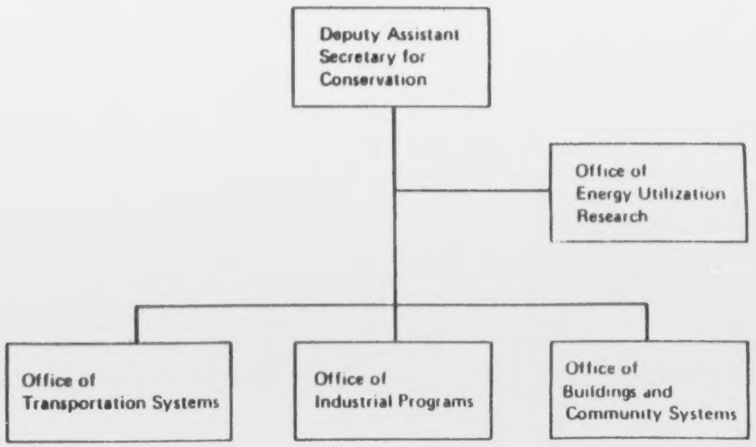
Deputy Assistant Secretary for Conservation
Office of Energy Utilization Research
Office of Transportation Systems
Office of Industrial Programs
Office of Buildings and Community Systems

FIGURE 1-2 Organization chart. Office of the Deputy Assistant Secretary for Conservation.

SOURCE: Office of Conservation

TABLE 1-1 Budget History ($ in millions)

	FY 81 Actual	FY 82 Actual	FY 83 Actual	FY 84 Actual	FY 85 Approp.	FY 86 Request
Buildings energy R&D	58.3	42.8	33.5	37.2	41.4	37.3
Vehicle and engine R&D	93.8	62.9	54.8	64.7	61.8	43.0
Industrial programs	43.0	28.8	27.9	33.5	31.9	35.5
Energy systems research						
Energy conversion and utilization	8.2	7.8	9.2	9.7	19.0	20.7
Electrical energy systems	35.0	21.3	17.2	18.4	20.7	10.0
Energy storage	51.9	38.5	25.7	25.6	19.6	16.1
Facilities	-----	-----	-----	-----	15.7	-----
	290.2	202.1	168.3	189.1	210.1	162.6

SOURCE: Office of Conservation

TABLE 1-2 Legislative Authority for Conservation Mission

Conservation Mission	Legislative Authorities
● Basic & Applied R&D	1. Federal Energy Administration Act of 1974 (P.L. 93-275) 2. Energy Reorganizaton Act (P.L. 93-438) 3. Federal Nonnuclear Energy Research and Develpment Act of 1974 (P.L. 93-577)
● Technology Development	4. Energy Policy and Conservation Act of 1975 (P.L. 94-163) 5. Energy Conservatin and Production Act of 1976 (P.L. 94 385)
● Technical Assistance	6. National Energy Extension Service Act (P.L. 95-39) 7. Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976 (P.L. 94-413) as Amended by P.L. 95-238
● Information Activities	8. Department of Energy Reorganization Act (P.L. 95-91) 9. Automotive Propulsion Research and Development Act of 1978 (P.L. 95-618)
● Guidelines and Standards	10. Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978 (P.L. 95-590) 11. Energy Tax Act (P.L. 95-618) 12. National Energy Conservation Policy Act of 1978 (P.L. 95-619)
● Federal Energy Management	13. Power Plant and Industrial Fuel Use Act of 1978 (P.L. 95-620) 14. Chrysler Corporation Loan Guarantee Act of 1979 (P.L. 96-185) 15. Energy Security Act of 1980 (P.L. 96-294)
● Congressionally Mandated Programs	16. Methane Transportation Research, Development and Demonstration Act of 1980 (P.L. 96 512) 17. Emergency Energy Conservation Act of 1979 (P.L. 96 102)

SOURCE: Office of Conservation

significant. It is worthy of detailed examination in an effort to enhance the planning process that guides the year-to-year selection of research projects to fund.

Multi-year planning, using a five-year budgetary projection, was initiated by the Office of Conservation in 1984 to provide a long-term perspective on the R&D projects within its portfolio. It resulted in the multi-year plan for fiscal year 1986 (DOE 1984a). This was followed in 1985 by the second multi-year plan for fiscal year 1987 (DOE 1985), which is examined in detail herein. The plan for FY 1988 is being prepared by the Office of Conservation.

DESCRIPTION OF THE MULTI-YEAR PLAN

The MYP describes and provides a priority ranking to approximately 150 projects, and shows planned levels of support in each of five subsequent years. A benefit of the planning process is the increased coordination of efforts among the four principal units of the Office of Conservation responsible for portfolios in the areas of transportation, industry, buildings, and energy systems. In addition the MYP shows the relationship between the various portfolios and the declared policies of the DOE and higher levels of government.

The MYP has not been a published document. It is promulgated internally within the DOE and displayed selectively to persons with an interest in the activities such as congressional staff persons and members of the energy R&D community. Thus, it was not intended to provide the outside reader with a comprehensive view of the programs, the planning methodologies, and the detailed rationale for decision making. Nevertheless, while aimed at an internal DOE readership, the documents do provide these views to a considerable extent, and constitute the major point of departure for this report.

The contents of MYP FY 1987 (DOE 1985) are summarized as follows:

- Chapter 1: Introduction A historical view of energy conservation is presented showing trends since 1972. The mission of the Office of Conservation is defined, and a statement of primary objectives is provided. The organization of the Office of Conservation by end-use sectors is described, the planning process is explained, and overall office strategy is articulated. Finally, a detailed analysis of the portfolio is presented using various measures of benefits, impacts, and other salient characteristics.
- Chapter 2: Planning Context and Methodology The national strategic context for the planning of the energy conservation program is presented, and the potential for future energy savings is estimated. An overview assessment of the longer-term (2010) U.S. and global energy supply is presented to show the comparative rates of depletion of known fossil fuel resources.

The role of uncertainty in planning is discussed in which a rationale for strategic planning is indicated. Macro-economic trends that influence the future demand for energy, U.S. energy imports, and the evolving structure of U.S. industry are mentioned.

Having provided the above contexts, the chapter presents a detailed set of "strategic objectives" for conservation, followed by a section on policy guidance and the federal role in which statements of the Secretary, citations from the National Energy Policy Plan (NEPP-IV), and the Office of Science and Technology Annual Report to Congress are compiled. In addition, reference is made to policy guidance in legislative mandates. A definition of the federal role in promoting energy conservation is provided. Finally, a section is provided on planning methodology, and the evaluation criteria for the prioritization of projects are stated.

- Chapters 3, 4, 5, and 6: Residential and Commercial Buildings, Transportation, Industry, and Energy Systems Research, respectively Each of these chapters has the following components:

  - Statement of objectives and strategy for the specific program area
  - Assessment of R&D needs
  - Project ranking for current fiscal year
  - Summary project descriptions and projected costs over a five year horizon

  These chapters also address such issues as energy user trends, status of the technologies, accomplishments of the programs, conservation potential, and private sector participation in the programs. The result of each chapter is an identification of technology needs, which provide a rationale for the selected portfolio and for the priority rankings.

The detailed contents of the MYP are cited extensively in this report. In particular, Appendix C summarizes the planning guidance of the MYP's chapters 1 and 2. Chapter 4 of this report summarizes the portfolio analysis of the MYP's chapter 1. Program level goals, objectives, and strategies that appear in the MYP's chapters 3 through 6 are also summarized in Appendix C.

PLANNING UNDER UNCERTAINTY

Any R&D planning process takes place in an atmosphere of some uncertainty. For example, the supply, demand, and price of various energy commodities often change from one year to the next. For any technological direction R&D may take, the time and cost to attain specific performance goals, and the very ability to attain those goals at all, is a major uncertainty. The MYP FY 1987, in a section entitled "Role of Uncertainty" (DOE, 1985, p. 26), states:

> . . . planning must ensure a fairly broad and diverse set of energy futures. One must envision both optimistic and pessimistic outcomes for each fuel, for each sector, for each time horizon, and for each objective. . . . The objective of portfolio planning under conditions of uncertainty is to contribute to the overall resiliency of energy end use systems. . . .

These kinds of uncertainties can be dealt with analytically by a variety of "strategic planning" methods and approaches. In this way, planners can satisfy several objectives in a balanced manner and can explicitly take uncertainty into account by analyzing alternative scenarios of future outcomes. The multi-year planning process can be significantly improved by exploring this line of attack (see Chapter 3 of this report).

There is another kind of uncertainty that is beyond the reach of any planning methodology--changes in law and administration policy. The Office of Conservation has been in a state of institutional flux, which hinders a stable and orderly environment for planning complex programs of technology R&D (ERAB, 1985b). The management staff of the Office of Conservation are to be commended for their ability to produce three successive MYP's (FY 1986, FY 1987, and FY 1988 currently in preparation), under conditions of limited resources for planning, rapidly changing policy direction, and congressionally mandated programs outside the context of an orderly planning process.

While the budget process from year to year is inherently unpredictable, energy conservation programs have annually experienced a series of major program redirections, goal reformulations, and budget reductions over the last several years. For example, the use of demonstration projects as part of a technology transfer strategy has been curtailed. At the same time, there is a new impetus to raise the level of cost sharing, which poses problems for funding long-term, high-risk projects. Private industry is not likely to participate in cost sharing for projects that are poor commercial prospects in the short term. In addition, DOE reorganizations have changed the senior management personnel, which results in different program and operational philosophies within the Office of Conservation.

All of this is exacerbated by uncertainty as to how Congress will ultimately deal with the massive federal budget deficit and how the deficit will affect specific program budgets, schedules, priorities, and even the ability to maintain a critical mass of research activities to support mission requirements and effectively deal with major national energy problems.

Clearly, it is very difficult for any government office to function properly let alone plan for the future when a sense of institutional stability is lacking and when previous priorities are declared irrelevant. Research programs require multi-year institutional commitments to attain a desired degree of continuity. When this is lacking and when careers within the organization are perceived to be threatened, it is very difficult to make a multi-year planning process work.

These problems are beyond the scope of the Office of Conservation to resolve in a direct way. DOE's own Energy Research Advisory Board (ERAB) has recommended that this situation be improved (ERAB, 1985b).

THE USES OF THE MULTI-YEAR PLAN

In the face of large uncertainties, the multi-year planning process attempts to impose a framework for sound decision making on R&D, and to provide an orderly basis for the Office of Conservation to function. The MYP is designed to be an internal management and planning tool for the office.

> The multi-year plan is a technical assessment of R&D needs and program priorities. It is not a budget proposal, nor does it make any assumptions about future funding levels. Rather, it presents a comprehensive set of structured inputs to the budget process in the form of recommendations, arranged in order of priority, from the technical managers (DOE, 1985, p. 4).

Nevertheless, the plan has become an important document in the policy development process. As Congress itself seeks guidance on how to reduce overall spending, the Office of Conservation is called upon by various congressional committees to explain its programs. Specifically, the following committees and subcommittees of Congress have an interest in one or more of the energy conservation programs, and hence in the MYP (ERAB, 1985b):

- Senate Energy and Natural Resources Committee
    - Energy Research and Development Subcommittee
    - Energy Regulation and Conservation Subcommittee
- Senate Appropriations Committee
    - Interior Subcommittee
    - Energy and Water Development Subcommittee
- House Science and Technology Committee
    - Energy Development and Applications Subcommittee
    - Energy Research and Production Subcommittee
- House Energy and Commerce Committee
    - Energy Conservation and Power Subcommittee
- House Appropriations Committee
    - Interior Subcommittee
    - Energy and Water Development Subcommittee

Unfortunately, the MYP's for FY 1986 and FY 1987 fail to communicate adequately an understanding of the programs, the achievements of DOE-supported research, and the national costs of neglecting critical areas of R&D. Of equal importance, congressional committees often require DOE to fund specific research programs, thereby reducing the scope of the planning process for independent decision making.

Policymakers within Congress, the administration, and DOE would do well to respect the independence of the multi-year planning process. At the same time, a smaller number of congressional committees with oversight of the Office of Conservation would help DOE manage its programs more efficiently. This is an opinion shared by ERAB (ERAB, 1985b).

MANDATED VS. DISCRETIONARY PROGRAMS

DOE's initiated (discretionary) programs are in general more technically sound and cost effective than those mandated by Congress. The latter include programs such as those required by the Electric and Hybrid Vehicle Act of 1976 and the Department of Energy Act of 1978.

For example, work on electric and hybrid vehicles appears to have resulted in no commercially useful technology being developed while the cost, especially of the demonstration phase, was very high. Research did focus attention on the basic shortcomings of such vehicles, i.e., the energy storage hardware, but these limitations were widely known before the program started.

Likewise, in seeking alternate, multi-fuel engines for advanced automobiles as mandated by Congress in 1978, DOE (and its predecessor organization, the Energy Research Development Administration) has sponsored research on gas turbine engines for about 15 years. But no commercially useful or cost-effective technology has yet emerged from such research. Moreover, research on the Stirling engine appears to raise the same issues as those for the gas turbine (see Chapter 3).

While these programs may still merit a place in the portfolio, DOE's multi-year planning process cannot properly make that determination because the programs are congressionally mandated. Therefore, Congress should use the MYP to better relate mandated projects to the overall program of the Office of Conservation, and the MYP should be strengthened accordingly. For a more detailed discussion of mandated research, see ERAB's 1985 guidelines report (ERAB, 1985b).

MULTI-YEAR PROGRAM COMMITMENTS

DOE's nonmilitary research programs have more than once been threatened with extinction and buffeted about in an almost ceaseless battle among the often sharply differing perceptions of the department itself, the Office of Management and Budget (OMB), and Congress. Thus, both in terms of objectives and in size of funding, the stability of the energy conservation program has been adversely affected (ERAB, 1985b).

According to ERAB, the Office of Conservation's budget authority has declined from $412 million in 1981, to $199 million in 1985. Only $169 million has been requested for FY 1986 (ERAB, 1985e).* The decline is even steeper if measured in constant dollars. However, much of this decline reflects a decision by the current administration to terminate demonstration projects. Thus, while the MYP seems to point toward funding commitments for several years, it does not assure them.

Government research offices in other countries also face a lack of budget stability for scientific and technical undertakings in competition with other national needs. Most other countries seem to deal better with the same kind of problems than does the United States. Each has a way of either evading or at least mitigating the share that is considered firm or nonrescindable.

For example, in West Germany budget allocations are made for a five-year period. However for each year the full, "firm" allocation in year one is followed by an 80 percent firm allocation in year two, and so on down to a 20 percent firmness share in the final year. Here, then, is a guaranteed minimum a program manager can count on. A process of annual negotiations is used to firm up the growing residual. Providing a rock-bottom, multi-year guarantee in this way is a practical policy. In the best of cases, such programs may indeed become fully funded for that period, depending on the merits of the research, and year-to-year competition for limited funds.

In Great Britain, contracts can be issued for five years and, in special circumstances, even longer. However, such contracts have so-called "break clauses," which can be invoked if Parliament cuts the budget. These are precautionary, but are hardly ever invoked in practice. All of this is covered by a three-year "rolling" budget process. Similarly, in Sweden there is a five-year planning horizon, with budgets set for three years, again on a forward-rolling basis. In Canada, too, the rule is a three-year program and budget "in principle."

These examples are mentioned to suggest that there are ways out of the year-by-year budget cycle for DOE research programs that require multi-year commitments for stability. Although it is difficult to simply transplant institutional procedures from one country to another, Congress, OMB, and DOE might find it useful to consider alternative approaches that have proved workable as well as beneficial elsewhere. Obviously, only Congress can make such changes.

The consequences of the lack of budgetary stability, are serious. An orderly and logical progression of research cannot be assured in the context of an uncertain annual future. A research staff is not easily reassembled when disrupted by a year of substantial funding decline. Even if a so-called "critical mass" in a program is maintained, there are losses when funds fluctuate in an uncontrolled manner. These include a loss of talent, retardation of scheduled progress, and a reduced commitment to attain objectives.

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*Compare ERAB estimates with Table 1-1. In general, actual expenditures are less than budget authority. Discrepencies between ERAB and the Office of Conservation for FY 1986 and FY 1987 are not explained. Recent data provided by the Office of Conservation indicates a FY 1987 budget request of only $69.9 million; a considerable downgrading of the program. However, in the past congress has usually appropriated more than the administration's request.

There is, moreover, the question of industry participation. In the total R&D framework, a sizable fraction of budgeted funds are transferred to industry to perform the required work. With the new emphasis on cost sharing, DOE's goal is to increase industrial participation. Such arrangements however, become untenable if they exist in the shadow of the possible curtailment of funds, except through the invocation of standard contractual termination clauses.

For example, in testimony recently before the House Subcommittee on Energy Research and Production, an R&D contractor in the batteries program said that planned budget cuts will result in the termination of a multi-year research contract (Glenn, 1986). Not only will researchers having unique knowledge and experience be laid off, but the company will lose money it has invested in new facilities, which were built on the good faith assumption of contract continuity.

Clearly, the future willingness of a competent R&D contractor to compete for federal funds becomes questionable. The impediment of budget instability thus works against the strengthening of industrial participation.

A MYP provides a workable and persuasive framework for research on energy conservation. To be most effective, such planning should be supported by a corresponding multi-year budgetary cycle.
A concerted effort at appropriate levels of government should be made to find ways of making longer-term commitments, using the European and Canadian approaches as examples.

THE NEED FOR THE OFFICE OF CONSERVATION

At a time when the international price of crude oil has fallen to less than $15 per barrel, with even lower prices expected as reflected in the price of crude oil futures on commodity exchanges, the economic wisdom of conducting research on energy conservation has been questioned. Moreover, federal program commitments now carry a higher-than-ever burden of requiring a demonstration of compelling public need before funds can be committed. These are valid considerations.

Nevertheless, there is still a compelling national interest served by continued federal support for research on energy conservation. Unfortunately, many decision makers fail to perceive that need. As the MYP FY 1987 states (DOE, 1985, p.3):

> Energy conservation plays a prominent role in overall national energy policy and is a critical element of a balanced and diverse energy resource system. Its continued development affords important opportunities for further improvement in energy and economic productivity, and for advancing the nation's competitive position in technology leadership and international trade.

Further, the mission of the Office of Conservation itself becomes particularly critical precisely at a time when world oil prices are decreasing. Specifically:

- A long-term international energy problem exists since liquid and gaseous fossil fuel reserves are finite and will ultimately be exhausted. The only unknowns are the ultimate rate of depletion, the distributional effects, and the pattern of future prices as exhaustion is approached. Time to exhaustion of petroleum (in itself an imprecise concept) varies with various forecasting assumptions. A recent major oil company analysis estimates 34 years, given projections of today's worldwide levels of supply and demand (British Petroleum Educational Service, 1985). (This estimate is based on existing proven world wide reserves only and makes no allowance for future proven reserves.)
- The long-term problem of oil and gas depletion is in no way diminished by a period of falling international crude oil prices. To the contrary, when short-term market conditions provoke falling prices, demand is stimulated and the rate of depletion of the limited resource is accelerated, thereby exacerbating the long-term problem. Moreover, in such periods investments for the purpose of developing future proven reserves decline. At a recent congressional hearing an oil industry expert predicted: "The total production impact by 1990 (of $15 barrel oil) will be a loss of 3.1 million barrels per day of liquids, or about 30 percent of total production capacity" (Wallace, 1986). Experience shows that when demand for oil marginally exceeds supply, as will inevitably happen again, prices can rise in quantum jumps.
- The private sector, in general, will invest in energy conservation technology when the payback on investment, calculated at prevailing energy prices, is no greater than about three to seven years depending on other opportunities for corporate investment. Even during periods of high oil prices, the private sector, while moving in the right direction, will not of itself ensure long-term energy security. This is because many technologies require long payback periods, appear too risky to a businessman, or require more capital than a single firm can assemble. During periods of lower oil prices, the private sector will avoid investment in energy conservation as clearly uneconomic, thereby moving the nation further away from energy security. In other words, the interests of the private sector are congruent with the national interest only when measured over a short time horizon.

The issue of energy security in the long term clearly transcends any year-to-year fluctuations in the international price of oil. Most of the world's petroleum is found outside the United States, where it is subject to interruptions of supply as a result of geopolitical factors that, as has been seen, can interrupt an orderly world marketplace.

For example, the Middle East and North Africa alone have reserves of 433 billion barrels dwarfing the U.S. reserves of only 27 billion barrels, and 75 percent of crude oil in the world is produced by governments, not by private companies (Wallace, 1986).

Although most U.S. oil imports are from Western Hemisphere sources, prices will continue to respond to the worldwide supply's geopolitical conditions. According to a recent analysis:

> As energy prices fall today, even though it provides a macroeconomic stimulus, it exacerbates the long-term security of supply problem and does so in a serious way. But because it is a long-term problem, it tends to be ignored. . . . Total funding costs, development costs and production costs are in the low $20 per barrel of oil (in the U.S.) as opposed to 50 cents to $2.00 per barrel in Saudi Arabia. . . . Before 1990 we will be more than 50 percent dependent upon oil imports. This is a significant constraint on foreign policy. (Schlesinger, 1986)

In 1973, as a result of Project Independence Blueprint, the United States made elimination of dependency on oil imports a goal of policy (FEA, 1974). The notion of energy security does not mean elimination of all oil imports, but the elimination of vulnerability to their interruption. The ability to reduce demand for energy by making conservation technologies available to the industrial, transportation, and building sectors is one of the key ways to reduce vulnerability to oil supply reduction and to the inevitable future price increases.

Clearly, the private sector cannot be expected to invest in conservation research with the motive of long-term energy security. Only the federal government can realistically make this investment (NRC, 1986a, b).

The DOE should give greater thought to such considerations and incorporate them in future MYPs. This would help readers more readily understand the importance of current investments in research on energy conservation.

2

THE FRAMEWORK OF GUIDANCE FOR MULTI-YEAR PLANNING

OVERVIEW

The multi-year planning process is grounded on a hierarchy of guidance from sources within and outside of the Department of Energy (DOE). The Office of Conservation interprets this guidance and draws implications for the multi-year plan (MYP).

The first section of this chapter provides a comprehensive description of the planning guidance, which appears in multi-year plan for fiscal year 1987 (MYP FY 1987). An effort is made to present it in a systematic manner because the committee found its presentation in the MYP to be nonsystematic.

The second section provides a critique of this framework of guidance. The committee finds the existing framework replete with problems, such as confusion of levels, lack of concreteness, and semantic confusion in the use of terms such as "objectives" and "strategies," which weaken the substantive intent of the guidance.

The third section responds to the critique by reformulating the entire hierarchy of office-level planning guidance in order to simplify it, to eliminate diagnosed problems, and to focus on the substantive criteria for actually guiding the planning process. While the recommended reformulation should itself be studied and modified, it represents a considerable advancement in communication of guidance for the purposes of planning the research and development (R&D) portfolio.

This chapter stops short of prescribing methodologies, which should logically be linked to the hierarchy of guidance. By reformulating the guidance following the idea of "quantification in principle," planning methodologies can be more readily and explicitly related to the guidance.

THE EXISTING FRAMEWORK

The MYP for fiscal year 1987 (MYP FY 1987) presents a complex and multi-level hierarchy of planning guidance. Table C-1* maps out a total of four levels of guidance, showing where each of 16 elements of guidance is given in the plan. The guidance is increasingly specific, proceeding from very general statements of national purpose at the higher policy levels, down to the specific objectives and strategies used by each of the four programs for transportation, industry, buildings, and systems. As seen in Table C-1, the guidance is dispersed throughout the document, and readers cannot easily place it into a readily understandable perspective.

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*See Appendix C for tables referred to in this chapter.

A discussion follows on each level of guidance: the higher levels including federal science and technology policy and DOE overall policy (levels 1 and 2 of Table C-1), Office of Conservation Planning Guidance (levels 3 and 3a), and specific program guidance (level 4).

Higher Levels of Policy Guidance

The MYP FY 1987, Section 2.3 (DOE, 1985, p. 30) presents an overriding framework for multi-year planning according to federal science and technology policy and DOE policy.

Federal Science and Technology Policy

Table C-2 shows a presumably overriding framework of objectives drawn from federal science and technology policy.

Department of Energy Policy

Table C-3 summarizes DOE's implementation policies within the broad general framework of science and technology policy.

The purpose of presenting this framework for the DOE mission as a whole is to show that the sources of guidance for the Office of Conservation are consistent with DOE policies, particularly those expressed in the National Energy Policy Plan (DOE, 1985).

Office Of Conservation Planning Guidance

Primary Framework: Mission, Objectives, and Strategy

Table C-4 shows the first three levels of guidance within the Office of Conservation as contained in Chapter 1 of the MYP. These constitute a coherent framework for the multi-year planning process that can be usefully critiqued and modified, as shown later in this chapter.

Supplemental Framework: Strategic and Specific Objectives

The plan's second chapter introduces what appears to be completely new and somewhat parallel frameworks, which serve to diffuse the primary guidance and make it difficult to focus on the intent of the office.

Specifically, two new kinds of objectives, respectively called "strategic objectives" and "specific objectives," are introduced.

Table C-5 shows the "strategic objectives," which presumably pertain to the same mission statement. While the term "energy security" first appears here, the eight objectives of Table C-4 can all be viewed as contributing to energy security. The phrase "efficient use of resources" essentially restates the first objective of Table C-4. The economic growth objective would seem to be served by several of the original eight objectives, i.e., as in Table C-4 items 1, 5, 6 and 8. This observation suggests that the framework of guidance can be consolidated.

Using the framework of Table C-4, the three "strategic objectives" of Table C-5 appear to represent a confusion of levels. Instead of adding to the understanding of how to plan within an orderly framework of guidance, this second set begins to detract.

Further confusion of levels and focus is added by yet another set of objectives, characterized as "specific objectives for DOE's energy conservation programs and R&D portfolio planning" (MYP FY 1987, p. 28). Each of these is supported by explanatory text justifying their selection. Paraphrasing for brevity, these are summarized in Table C-6. These seven specific objectives are then retitled, rephrased, and reordered in summary under a new heading "Conservation Mission Objectives and Mission Related Objectives" (DOE, 1985, p. 30), as shown in Table C-7.

This supplemental framework introduces many kinds of worthwhile objectives, but their presentation is diffuse and does not focus on an orderly planning procedure.

Criteria for Setting Priorities and Evaluation

DOE's Office of Conservation is a unique source for a series of research efforts that are generally not seen as naturally linked given their drastically different requirements regarding of short-term vs. long-term funding, basic research vs. demonstration, industry participation, and modes of technology transfer. Moreover, it is not clear how the research would fit into the wider agendas of the fields in question.

For example, in the area of transportation, only a handful of domestic automobile manufacturers need be integrated into a comprehensive national research agenda for energy efficiency. Further, transport mainly uses petroleum as its energy source. By contrast, in the field of buildings, the National Association of Home Builders (NAHB) alone has nearly 100,000 members. Their products--houses--consume energy from a variety of sources including electricity, petroleum, natural gas, and renewable energy.

This diversity is reflected in the multi-year planning process by the autonomy that each program is allowed in order to develop its own methods and criteria for setting priorities. In the multi-year planning process, each office is asked to respond to a common set of criteria. The plan states, ". . . each [program] office was allowed flexibility in prioritizing its list, in accordance with several major project attributes" (DOE, 1985 p. 36). These are summarized (paraphrased and edited) in Table C-8.

While individual projects and programs appear to be subject to reasonably rigorous technical scrutiny, the analyses vary considerably between programs. Further, the plan does not report the mechanisms by which the analyses are to be conducted. In fact, that these mechanisms exist at all would not be apparent to uninitiated readers. Moreover, their nature and function appear to be the subject of some confusion outside DOE as reported to the committee at its roundtable (see Appendix A). Explicit criteria and methods should be described and included with each program's priority list within the MYP.

Specific Program Office Guidance: Goals, Objectives, and Strategies

The individual guidance statements of the four programs are at the bottom of the above imposing hierarchy of guidance. They attempt to focus on the particular needs of each program within the overall framework. Tables C-9 and C-10 summarize three additional levels of guidance, in the form of goals, objectives, and strategies for the four programs. These tables restate the goals, objectives, and strategies in a generic manner. References to either specific technology or fuel targets appropriate to each of the four programs have been deleted in order to display clearly either commonality or divergence of approach.

CRITIQUE OF THE FRAMEWORK

Within this process the multi-year planning process is an attempt to reconcile a broad mission statement and set of policy objectives articulated by the upper decision-making levels within DOE, as presented by the National Energy Policy Plan (NEPP), with specific program priorities developed by the directors and staff of the four programs. The framework of guidance should guide program managers on formulating specific planning methods, identifying candidates for the portfolio, and evaluating each project within the portfolio candidate list. However, the way the guidance is currently presented serves to confuse the reader, and does not effectively serve its intended purpose. The following problems characterize the framework of guidance:

- A confusion of levels, with statements repeated too often and at inappropriate places.
- Too many levels of guidance presented; there is a need for consolidation.
- Parallel levels of guidance, such as 3 and 3a of Table C-1, create confusion not clarity.
- A semantic confusion in the use of terms such as "goals," "objectives," "strategies," and "criteria." Goals and

objectives, in general, should describe quantifiable end points, achievement of which can be measured in principle. Strategies should be stated as concrete actions that move towards specific goals and objectives. Criteria should be measures of appropriateness, which can relate to goals, objectives, or strategies.

- The guidance is scattered throughout the plan; no map or chart is given to help orient readers.
- The guidance is often too general and does not help planners focus on concrete and quantitative criteria.

The criticism is of more than academic significance. Confusion in the presentation of planning guidance may confuse the planning process itself. As a consequence, the results may fail to reflect the full range of intended policy purpose. Each program could develop better planning methods by stating a single, hierarchically clear framework of policy guidance, and then providing explanatory text that shows:

- Source of guidance,
- Explanatory background, and
- What it means in terms of program expectations.

The MYP was originally designed as an internal working tool for program managers. However, as seen in Chapter 1, it has also come to be an important frame of reference for persons outside DOE including members of Congress, other federal agencies, and energy researchers. The current manner of presentation of the planning guidance detracts from the Office of Conservation's task of communicating its plans to the policy and research communities.

While presentation can be improved, the Office of Conservation is to be commended for pursuing hierarchical planning, and for attempting to ground its multi-year planning process as directly as possible on higher-level policy guidance. This demonstrates a commitment to communicate that guidance to program managers.

REFORMULATION OF THE OFFICE OF CONSERVATION'S PLANNING FRAMEWORK

Overview

In view of the problems indicated, the framework of planning guidance should be reformulated and consolidated to remove sources of confusion and to provide less diffuse and more concrete statements at all levels. Toward that end, office level guidance statements should be measurable in principle. This will help planners to devise methods and tools that can demonstrate the degree to which a particular project or program measures up to a given purpose. This principle does not imply imposition of rigid quantification procedures. It does imply clarity of purpose and the ability to make measurements, within appropriate degrees of approximation, as planning managers see fit.

Table 2-1 shows a reformulated hierarchy of primary planning guidance (level 3 per Table C-1) in which the plan's "criteria" level is eliminated as well as the supplemental framework (level 3a per Table C-1). The guidance previously contained in "criteria" should be merged with "strategies," as shown herein, and should enter into the planning methodology of each office. This consolidates the guidance and removes semantic confusion between the terms "strategies" and "criteria." Table 2-1 also makes explicit the source and target of guidance provided by each level.

Restatement of Mission

In the face of this heavy load of guidelines, objectives, and strategies, improving the economic efficiency of energy end-use is at the heart of the mission. Therefore, the Office of Conservation's mission statement (shown on Table C-4) should be rewritten to read as follows:

- The mission of the Office of Conservation is to accelerate the development of energy end-use options that are economically efficient and that can ultimately be commercially applied.

This mission statement places the emphasis on the economics and ultimate commercial potential of the technology. Currently, projects are evaluated primarily in terms of potential energy savings, and choices are made on that basis. Referring to Table C-4, economics would appear to enter as objective 1 as a direction to "improve the efficiency by which resources are used in the economy," as objective 8 to "reduce consumer energy costs," and again at the next level of "planning strategy" as a directive to "pursue the highest potential return on investment in terms of making a significant contribution to the goals and objectives of the Office."

Guidance given in this manner is not clear. In fact, planning and evaluation is guided by perceptions of energy savings consistent with the current mission statement. To ensure that choices are made with economics as the primary decision focus, with energy saved as subsidiary, the mission statement should be modified as recommended.

The emphasis on energy savings may have been appropriate when energy appeared to be in permanent short supply and the cost, especially that of oil, rising. However, given the current price of oil at well under $15 per barrel and the expectation that it will fluctuate in price over the long term like any other commodity on the world market, it is no longer appropriate to plan new energy technologies as if the price of oil were to rise exponentially.

Changing the research emphasis from energy savings to economic efficiency and commercial feasibility requires rigorous use of economic data, and the formulation of baseline scenarios against which to measure the economic impact of various R&D investment decisions. Given economic and technological uncertainties, the Office of Conservation

TABLE 2-1 Reformulated Hierarchy of Planning Guidance for the Office of Conservation

Level	From	Through	To
Mission	Congress & Office of Science & Technology Policy	Secretary of DOE	DAS/C[a]
Objectives	Secretary of DOE	DAS/C	Programs: transportation, industry, buildings, systems
Strategies	DAS/C	MYP	Programs: transportation, industry, buildings, systems
Specific program planning guidance	Program managers	MYP	Program planners

[a] Deputy assistant secretary for conservation.

needs a strategic planning process (see Chapter 3). Having a correct mission statement to guide this process is essential to give the plan a clear focus.

Restatement of Objectives

The eight-part statement of objectives (Table C-4) should be consolidated and reformulated to focus the multi-year planning process as follows:

- Increase energy security,
- Better understand and mitigate adverse health and environmental effects; and
- Improve U.S. competition in international trade.

These three objectives consolidate and refocus the original eight, while ensuring "measurability in principle." Increasing energy security is the first objective, since it is uniquely related to the purposes of conservation in the long term. The second and third items (Table C-4) of the original objectives, which essentially describe aspects of energy security, are thus incorporated.

Understanding and mitigating health and environmental effects are key to removing constraints on the further use of coal, such uses being economic and contributing to the long-term energy security of the United States. There are other problems in the utility industry and elsewhere where health and environmental concerns need to be addressed as ways of advancing long-term energy security. This objective consolidates the original items 4 and 7.

Improving U.S. competition in international trade again relates back to the reformulated mission statement. It is not currently a primary objective, but is stated as a subsidiary (item 6). It merits standing as one of the three primary objectives because successful conservation technologies to be developed will not only improve energy efficiency, but also the U.S. competitiveness in domestic and international markets.

To the extent that such technologies contribute to decreased energy use worldwide, they help to stabilize the price and availability of energy and contribute to U.S. energy security. The objective 5 of strengthening U.S. technical leadership is a corollary to improving the U.S. economic position in the international marketplace.

Restatement of Strategy

Having proposed a single, newly formulated "mission" statement and a set of three concise "objectives" to clarify and focus the goals of the Office of Conservation, it is further recommended that fourth-level guidance statements--"strategies" (DOE, 1985, pp. 5, 51 summarized on Tables C-3 and C-4), "strategic objectives" (DOE, 1985, pp. 28, 29 summarized on Table C-5), and "criteria" (DOE, 1985, pp. 36, 37 summarized on Table C-8)--be consolidated into one level of strategy statements. A single set of strategy statements as specific actions to be taken within the multi-year planning process, are recommended:

1. Pursue projects with the highest expected potential return to the U.S. economy as a whole and to U.S. energy security, taking into account:
    - The value of fuels saved,
    - Contribution to technology exports,
    - Economic benefits of environmental improvement,
    - Contribution to overall industrial productivity,
    - All economic costs (i.e., research, development, demonstration, production, and marketing), and
    - Reduction of vulnerability of critical economic sectors to imported energy restrictions.
2. Consider the short- (0-3 years), medium- (3-10 years), and long- (10 plus) term mix of the portfolio, in terms of expected time to first commercial application as follows:
    - Ensure a long-term energy technology base,
    - Emphasize medium-and long-term projects of higher risk,
    - Target the greatest level of private cost sharing for those projects nearest in term, and
    - Provide diversity through the consideration of a variety of "times to payoff."
3. Seek to balance the portfolio within the programs based on the ability and likelihood of industries in each sector to conduct their own research, taking into consideration:
    - Historical and current data on industry R&D expenditures as a percentage of revenue,
    - The wider research agenda of each sector, and
    - The national significance of federal support to each sector.
4. Evaluate the technology transfer requirements and potential of projects at their inception by:
    - Taking technology transfer requirements into consideration in setting program priorities, and
    - Seeking to involve the private sector in the planning process through committees, symposia, and other interactive mechanisms.
5. Explicitly document decisions on new initiatives, continuation of ongoing programs and projects, and project terminations, as follows:
    - Define programs and projects in a consistent manner from one year to the next (the FY 1986 and FY 1987 plans lack continuity and consistency in program definition).

- Provide intermediate goals, milestones, and budgets for each program so that progress can be tracked. Report the status of each program in terms of the relationship to these goals and milestones.
- Provide criteria for project phaseout in terms of achievement of goals, altered prospects for success, ground rules for continued support, and other factors.

These proposed strategies consolidate those in previous MYP's and extend the concept of "measurability in principle." Strategy 1 is a more precise interpretation of the economic emphasis contained in the newly formulated mission statement. Strategy 2 speaks to the most salient aspect of portfolio diversity as an a priori quantitative planning decision. Strategy 3 addresses the balance of the portfolio between programs, taking into account data on the technology user sectors. Strategy 4, while nonquantitative, addresses the need for more explicit and concrete accounting of technology transfer issues in the planning process. Strategy 5 seeks to clarify the documentation procedures.

Clearly stated and implemental strategies are particularly important because it is at this level of guidance that the Office of Conservation is most flexible and can demonstrate the greatest level of creativity and constructive direction.

Restatement of Program Level Guidance

The level of "goals" in Table C-9 should be eliminated. Guidance at this level should be reformulated in terms of objectives and strategies only.

A common set of objectives and strategies should be stated in a generic manner, so each program can select statements and put them into a priority order that fits the circumstances. Then, each program should describe the methods used to measure achievement of objectives and the rationale for the selected strategies.

The definitions of "strategies" and "objectives" are highly contextual. For example, "transfer R&D results to the private sector" is stated as an "objective" appropriate to any of the four programs. While it meets the criterion of being quantifiable in principle, technology transfer can also be viewed as a "strategy" in pursuit of other objectives. Whether technology transfer is used as either an objective or strategy depends on the context and judgment of planners. The burden of measurement is higher on an objective, since a strategy refers only to a concrete action.

Restatement of Program Objectives

The four sets of program objectives should be restated as results that can be measured in principle. The following program objectives could be selected, given priority, and applied to the specific requirements of each program:

- Increase efficiency of energy use,
- Enhance fuel use efficiency,
- Facilitate fuel substitutions,
- Advance scientific understanding of basic processes,
- Expand the knowledge base of new technologies,
- Accelerate introduction of new technology,
- Transfer R&D results to the private sector and the consumer, and
- Develop improved techniques, processes, and materials.

Each of the above can be measured in principle. Each project and the portfolio as a whole can be charted against each objective as defined, using some kind of analytical methodology and professional appraisal. This list of objectives is not intended to be definitive. Each program office will want to formulate its own priority listing and to rationalize the choice as follows:

- Show how the particular choice of program objectives are related to the higher levels of planning guidance.
- Develop more specific technical targets within the framework of the objectives chosen.

By relating the specific objectives for each program to a generic frame of reference to be used by all programs, coordination of the planning process can be greatly facilitated.

Restatement of Program Strategies

The program strategies, as shown in Table C-10, should be reformulated as a set of actions to be implemented in a concrete manner. Again, the specific statements below are only examples for consideration by the Office of Conservation, rather than definitive recommendations.

- Identify use of energy by mode and fuel,
- Consider risks, costs, and net economic benefits,
- Consider how benefits accrue to fragmented industries,
- Use technology assessments and retrospective program reviews as inputs (see Chapter 3),
- Involve the private sector in the planning process, and
- Use cost sharing by the private sector as a means to enhance technology transfer.

These strategies can be implemented by specific planning procedures and methods that may vary among the four programs. By defining a framework of strategies in a generic way to be tailored to each program, the coordination achieved through the objectives framework is reinforced.

By implementing these suggested changes to the framework of planning guidance, the Office of Conservation will provide an important prerequisite to a more effective multi-year planning process, as described in the following chapter.

3

THE MULTI-YEAR PLANNING PROCESS

OVERVIEW

This chapter presents a critique of how the Office of Conservation carries out various aspects of the multi-year planning process.

The first section deals with the need for a full-time director for the multi-year plan (MYP). The creation of this position will help to solve many of the management problems identified in this report.

The second section examines several aspects concerning the management effectiveness of the office as a whole, as it relates to the multi-year planning process. Recommendations are made for improving internal and external coordination of planning, initiating projects and setting milestones, facilitating orderly phaseout of projects, and orienting the program toward generic research as against product development. Finally, the role of the national laboratories in the multi-year planning process is critiqued and ways to improve the uses made of them are recommended.

The third section briefly focuses on three kinds of strategic inputs to the multi-year planning process: retrospective program reviews, technology assessments, and inputs from the Department of Energy's (DOE) Basic Energy Sciences (BES) program. These elements are already in use, but their application to the multi-year planning process is not apparent in the MYP. Program reviews and technology assessments should be explicitly referenced in the MYP as supporting planning decisions, and the office should enlarge its interface with BES in order to improve its awareness of opportunities related to more generic research.

The fourth section recommends that technology transfer considerations should enter into the planning process, and that objectives related to technology transfer be incorporated into every program and project. Cost-sharing of projects with the private sector is viewed primarily as a strategy for improving technology transfer for those projects that are toward the low-risk, short-term end of the spectrum. Cost-sharing strategies should be well articulated and tailored to the needs of each program and each project.

The fifth, and final section, examines the issue of planning methodologies and tailoring them to the needs of each program. All such methodologies should be grounded on a common set of office-wide criteria, i.e., planning guidance as articulated in Chapter 2 of this report. In addition, formal "strategic planning" methodologies have a place but need to be carefully evaluated and applied to the particular needs of each program.

NEED FOR A PLANNING DIRECTOR

DOE has created a complex and multi-faceted planning process for research and development (R&D) projects sponsored by its Office of Conservation. That process, which results in the MYPs now in their third cycle of preparation, lacks a full-time planning director and appropriate staff. Instead, a special assistant to the deputy assistant secretary for conservation is assigned the role of planning director, as one of many responsibilities to be carried out during the year. The staff for the process is similarly designated on an ad hoc and part-time basis.

This situation contributes in part to many of the weaknesses of the MYP as described in this and the previous chapter. Therefore, a full-time director should be appointed and an appropriate full-time staff created. The duties of the director should include the following:

- Maintain an adequate data base to support all dimensions of the planning effort, including current technology assessments and retrospective program reviews.
- Organize the planning guidance, communicate it to the various program managers, and act as a center of information on all matters pertaining to multi-year planning.
- Identify and select candidate methods for use in the multi-year planning process, subjecting them to rigorous evaluation and testing prior to implementation. This should include methods for office-wide application, as well as specific ones tailored to the needs of each program office.
- Facilitate a coordinated decision process between the deputy assistant secretary and each of the program managers.
- Facilitate outside input to the planning process from interested members of the R&D community.
- Assist in coordinating the various annual operating plans of the Office of Conservation with the MYP.
- Document the decision process and the results of planning.
- Prepare the MYP itself to both guide the actions of the program managers, and serve the secondary purpose of communicating the MYP to an outside audience of policymakers and members of the energy R&D community.

The planning director should support the decision-making process by providing a consistent and coherent internal framework and data base for multi-year planning. This activity should not impinge on the deputy assistant secretary's authority or that of the program managers. By maintaining a high level of coordination and managing the process, program portfolio decisions by the deputy assistant secretary, in consultation with the program office managers, will be made more efficiently and with a higher level of confidence.

Designating a planning director may entail additional costs at a time of tight federal budgets. However, it would reduce the existing time commitments of other senior staff, thereby contributing to overall office productivity. In addition, an improved planning process will contribute to a more effective conservation program in general.

The level of resources formally committed to the planning process should be proportional to the size of the portfolio. They should be considered part of the overhead expense of managing a complex R&D effort, which, even with recent budget cuts, involves an annual expenditure of $169 million.

Assigning a budget for the planning function should take into account several factors: the amount now spent on an ad hoc basis, the planning tasks that need to be reinforced, the increased efficiency of planning that is achievable, and the benefits of a process that will in general produce a higher level of confidence in the outcome. In addition, DOE should look at how much other research organizations, such as the Electric Power Research Institute (EPRI), the Gas Research Institute (GRI), and the energy R&D establishments of other countries, spend on planning as a percentage of their overall budget.

MANAGEMENT EFFECTIVENESS

Coordination

Coordinating the planning and management of programs takes place both at an internal and external level. The former refers to coordinating the Office of Conservation's four programs. The latter relates to coordination between the programmatic goals and efforts of the office, the private sector, other government agencies and departments, and energy conservation programs of other countries.

Internal Coordination

The R&D portfolio is developed independently by the four program offices under broad guidelines (see Appendix C) as they develop prioritized lists of projects using different sets of planning criteria, without apparent coordination at the level of the deputy assistant secretary for conservation. Input into the planning process at the office-wide level occurs only during the budgetary phase, when final decisions on funding are made at the margins of the prioritized program lists submitted by the four program office directors (DOE, 1985, p. 38).

External Coordination

All Office of Conservation programs have substantial interactions with the non-DOE research community through workshops, symposia, joint committees, publications, and technical review panels (DOE, 1985, pp. 56-61, 102-106, 136-143, 178-179, 207-212, 240-241). These activities should be continued. Interactions with other DOE offices, other federal agencies, and energy conservation programs in other countries are not mentioned in the MYP.

The Office of Conservation has made considerable efforts to collaborate with EPRI, GRI, and other elements of the private sector that participate or are interested in the outcome of federally sponsored research on energy conservation. Still, such interaction can be improved and strengthened. In general the goals of the private sector are not congruent with DOE's mission and objectives. Thus, there is a need to find more common ground between them if industry is to share costs and participate in DOE programs to a greater degree (see later section: "Technology Transfer and Cost Sharing Strategies").

The Office of Conservation would also benefit from coordinating its programs with those in other federal agencies and departments, and with the extensive energy conservation programs that exist in Europe and Japan. Distinct financial and technical gains could result from joint efforts especially with the foreign programs that have greater fiscal stability and longer-term funding horizons. The Office of Conservation participates in international energy forums, but the influence, need, or benefit, if any, of such participation is not reflected in the MYP.

Milestones and Project Initiation

As part of the long-range planning process, the four program offices independently develop a five-year budget projection and general statement of work for each of the projects they currently support. However, a detailed presentation of specific program goals, milestones, new project starts, and project terminations (or decision points) is given only on a two year basis in the respective annual operating plans (DOE, 1984b,c,d,e) prepared by each program office. A limited attempt at a five year projection of milestones is made only by the Office of Transportation and the Office of Industrial Programs in their annual operating plans (DOE, 1984e,b). A major difficulty encountered in scheduling programs within the context of a long-range plan clearly relates to the lack of year-to-year consistency in the federal budget for energy conservation research (see Chapter 1). Nevertheless, there are two aspects of program scheduling and timing--how projects are initiated and phased out--that could be significantly improved even in the absence of long-range funding stability.

In the current planning context, a new project (or a change in direction of an existing project) typically cannot be implemented with less than a two-year lead time. This delay results from several factors: (1) the elaborate procedures by which new initiatives are first integrated into the long-range plans of the program offices and then into the office-wide plan; (2) uncertainty over available funding for new starts in the following fiscal year; and, (3) the slow and uncoordinated procedures by which older programs are phased out (or redirected) to allow for new R&D projects to be initiated within the context of a constrained budget.

Given that one of the major goals in federally sponsored energy research on conservation is to accelerate by five to ten years the availability and market penetration of new processes and materials, it is unacceptable to have a delay of two or more years in the initiation of new projects with a high payoff potential. The DOE should streamline the mechanisms through which new initiatives can be funded in a timely manner, even if this process involves either an accelerated phaseout or redirection of existing programs.

In some federal agencies and departments (e.g., National Institutes of Health and the Department of Defense), the maximum delay is nine to twelve months between the receipt of a new proposal, if it is approved, and the initiation of funding. It would not be unrealistic for the Office of Conservation to achieve a similar timetable for the initiation of new projects with a high payoff potential.

Phaseout of Projects

As in many publicly funded projects, certain DOE conservation programs seem much easier to start than to stop. There appear to be a number of reasons for the difficulty in terminating programs: (1) little or no effort in looking back at how much and how well original projections were achieved; (2) using the wrong or inadequate criteria for judging accomplishments along the way; (3) setting up unrealistic objectives at the start; and (4) an abundance of promoters and potential contractors who make optimistic assumptions and extravagant claims for new technologies based on technical and commercial promises that are unattainable (see ERAB, 1985b for additional discussion of the phaseout problem). Some of these problems occur because congressionally mandated programs are inserted without reference to the criteria contained in the multi-year planning process (see Chapter 1).

The advanced automotive propulsion programs are a case in point. Research on the advanced automotive gas turbine program, begun in the early 1970s, sought a 30 percent improvement in fuel economy over existing spark-ignited engines. Yet, 25 years of research by private industry that preceded the federally funded program had shown that the gas turbine or Brayton cycle engine has very good fuel economy when operated at its optimum design point, as it is mostly used in commercial aircraft. But it has very poor part-throttle fuel economy (much less than internal combustion engines) as experienced in normal urban driving. Even with heat exchangers to recapture and use some of the exhaust energy, it begins to approach but does not yet exceed the efficiency of the internal combustion engine in normal urban or highway use. Yet, a target of 30 percent improved fuel economy was set for the program, which is a highly unlikely goal. Incremental gains have been made in gas turbine fuel economy since the program was started, but at a substantial increase in cost and complexity of the hardware.

Today, a retrospective look would show that after nearly 40 years of private and then publicly funded research, no automotive gas turbine engine has reached the stage of commercialization. How should the multi-year planning process respond to this kind of program history? When should phaseout be initiated? Despite these questions, there may be good and valid reasons for continuing this program. The point made is that the MYP does not even raise the issue.

Another example relates to the promise offered by a thermodynamic analysis of the Stirling cycle engine, which shows better potential fuel economy at part throttle than the internal combustion engine. However, after seven years of funding of a hardware development program, the Stirling engine, also falls short of fuel economy goals, while cost, complexity, and specific weight make it unlikely ever to be commercially viable. Again, there may be good and valid reasons for continuing research, but the MYP should show clear justification in relation to project continuation and phaseout criteria.

DOE seems to be still pursuing these two technologies because they were mandated by Congress, and there appear to be no better technological alternatives to automotive fuel economy.

The multi-year planning process should be able to make convincing retrospective assessments that could influence decisions on these and other mandated programs (see Chapter 1). The mandated programs should be subject to the same program analysis as discretionary programs, and the results should be included in the MYP. This will provide Congress with valuable assessment information to make more informed decisions about the mandated programs.

Product Development vs. Generic Research

Both the electric and hybrid vehicle programs and the gas turbine and Stirling engine programs clearly have been "product development" efforts, even though DOE policy gradually has shifted toward funding more fundamental, generic research. DOE efforts could be much more effective if underlying problems and bottlenecks to commercialization were determined first, then more fundamental generic research were sponsored, to solve the basic problems. The latter would include research on materials, combustion, heat transfer, and cooling problems.

Indeed, the Office of Conservation has recently shifted to the more generic and underlying research for advanced heat engines. The transportation program now focuses on developing structural ceramics to increase operating temperatures (higher Ts) and reduce heat losses in engines. Accordingly, there has been a phasedown of engine development. In research, a particular product may prove unsuccessful commercially, but the underlying generic information is always useful. The Office of Conservation should use the multi-year planning process to assess when basic research begins to approach a commercial product development. This would help provide information necessary for decisions on requiring technology transfer and increased cost sharing, or on orderly phaseout of a program.

Role of National Laboratories

The DOE national laboratories have an important role both in the conduct of federally sponsored research and in the planning and management of Office of Conservation programs.* The national laboratories are involved in the multi-year planning process through the submission of new project proposals and opportunities to comment on drafts of the MYP. In addition, the national laboratories play a "lead-lab" role in several major areas of energy conservation research and assist the program offices in the management of their projects. In this managerial role, the national laboratories can also influence the multi-year planning process.

The role of the national laboratories has both positive and negative attributes. For one thing, the national laboratories provide continuity in research programs and serve as an "institutional memory" to a greater extent than other institutions or the Office of Conservation headquarters staff. They also have a large corps of professional staff with expertise in and a long-term dedication to the research objectives of energy conservation. By applying a multidisciplinary approach to research, the national laboratories have played a major role in the success of programs from the outset.

On the other hand, the decentralized management of energy conservation programs can detract from the effective coordination of program plans within the various program offices and at the office-wide level. Further, it is bureaucratically cumbersome to pass funds through national laboratories to universities and other institutions. Inevitably, that involves delays beyond those encountered when the funding is administered directly from DOE headquarters.

It is true that staffing limitations at DOE headquarters have imposed the need for the use of extensive field management in many areas of energy research. It is also true that the national laboratories and their associated operations offices throughout the United States are a valid alternative to direct management from DOE headquarters. However, DOE should seek to reduce the extent of decentralized program management.

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*ERAB (1985b) reports that the eight multi-program national laboratories have a combined budget of about $3 billion for fiscal year 1985, but that only $60 million is for discretionary R&D, including conservation and solar projects. Thus, in terms of an individual lab's budget, the impact of the Office of Conservation programs is quite small.

There is a clear need for additional funding to attract and retain top scientific managers within the Office of Conservation. This should be done in a manner consistent with recent recommendations by the Energy Research Advisory Board (ERAB), which clearly states that "the focus of DOE R&D program management should be on assignment, control, and evaluation of R&D products, and not on continuing micro-management of the execution of the research programs" (ERAB, 1985b).

If DOE cannot increase the number of career management staff in the Office of Conservation because of funding limitations, a greater number of two-year rotating positions could be established to permit qualified scientists from the national laboratories and other DOE contractors to perform management functions at headquarters on a temporary basis. The resulting admixture of professional management rotating staff and scientists would also help update and revitalize the scientific perspectives of the headquarters staff. The price, however, would be an assured staff turnover and the consequent loss of continuity and experience.

Another suggestion is to supplement the headquarters staff by still shorter-term consultants from industry, national laboratories, or academia from the United States and abroad who could assist in the identification of new initiatives as well as long-term planning in specific areas.

STRATEGIC INFORMATION INPUTS

This section describes how certain strategic informational inputs can enhance the multi-year planning process. These include: (1) retrospective program reviews; (2) technology assessments; and (3) interface with DOE's BES program.

Retrospective Program Reviews

The planning process does not appear to include an in-depth, retrospective, project-by-project examination of what has previously been achieved with respect to energy savings, cost and benefit implications, and technology transfer effectiveness of past programs. Nowhere is it obvious that information on previously funded programs is accumulated and compared with the projections for those programs when they were originally funded.

Such retrospective reviews should be included in the planning process. They are extremely important in sharpening the planning and forecasting process, in validating the cost and benefit models, and in setting more cost-effective priorities for discretionary programs. They would also appear useful in helping the Office of Management and Budget (OMB) and Congress evaluate the effectiveness of mandated programs.

Further, an appraisal of past successes and failures should enhance the technology transfer process. The private sector is much more agreeable to sharing costs with a proven winner than a frequent loser.

Technology Assessments

Technology assessments are important decision tools for planners and for the policymakers. Indeed, Congress maintains an Office of Technology Assessment (OTA) for that purpose (see OTA, 1983, 1985 for examples of technology assessments in the energy area).

The Office of Conservation supports occasional technology assessments, such as the work contracted to Battelle Pacific Northwest Laboratory (Hopp et al., 1981, 1982). However, they have been limited to identifying of technical opportunities and have not addressed the full range of issues usually considered by an OTA technology assessment, which would serve the particular needs of the multi-year planning process. Additional examples of technology assessments in the energy area include a National Research Council (NRC) report on diesel engine development and increased use (NRC, 1982a), a National Science Foundation study of biomass energy systems (Johnson et al., 1980), and a recent appraisal sponsored by the EPRI of how electrical technology can contribute to industrial production (Schmidt, 1984).

The MYP includes sections by each program office entitled "Major Areas of Technology Need" (DOE, 1985, pp. 61, 106, 144, 181, 201, 232). These are each followed by sections on "Areas of Planned Program Emphasis." Thus, the plan appears to reflect a variable degree of technology assessment inputs. However, no reference is made to any technology assessment studies as an informational baseline to support the office's perceptions of technology needs.

Technology assessment methodologies are extremely diverse, variable in resource commitment and relationship to the decision process. It is beyond the scope of this report to explore this topic in depth and to recommend specific approaches for the Office of Conservation. In principle, technology assessments can provide very useful inputs to the multi-year planning process, and should be shown more explicitly in the MYP.

Technology assessments should measure the degree to which a DOE investment in specific technologies contributes to the mission and objectives of the Office of Conservation. The analysis of comparative costs and benefits can readily be adapted to include the economic value of any acceleration period achieved by the DOE program. Similarly, a measure of each of the three major objectives (i.e., energy security, environmental benefits, and contribution to international competition) can be obtained as integral components of an appropriate cost and benefit methodology.

A technology assessment should also evaluate what other countries are doing to develop conservation methodologies. The committee's roundtable (see Appendix A) included representatives from conservation programs in Canada, Denmark, France, Germany, Japan, Sweden, and the United Kingdom. A broad international forum on conservation technologies would be timely to initiate with these and other countries. Jointly sponsored R&D efforts should be considered to the extent that they advance U.S. energy development.

While it is assumed that a search for applicable technologies goes on continually among the Office of Conservation, its contractor community, and the outside world, the office should ensure that this is an organized and well-executed effort. The objectives should be to avoid duplication of efforts and to identify relevant technologies elsewhere that might be adaptable for conservation purposes in the United States (see NRC, 1986a).

Interface with Basic Energy Sciences Program

The paths from energy production to end use involve a sequence of physical processes, each of which is embedded in a larger societal framework. There is nothing intrinsic to the chemical and physical transformations at the beginning of the sequence that makes them more closely allied to basic and applied science than those at the end of the sequence. It is culture that endows energy generation with a degree of glamor and scientific seriousness, and considers energy end-use to be mundane and less worthy of research efforts.

Why does this polarity occur? One obvious variable is scale: energy production tends to be concentrated whereas energy conservation tends to be highly distributed. There are only hundreds of offshore oil installations and nuclear power stations compared to millions of small electric motors, kilns, and light bulbs. Scale of technology makes a difference when it comes to pooling resources to attack the technical aspects of a problem, which may be why there are first-class departments of ocean engineering, gas and electric research institutes, and laboratories of nuclear science, while there are relatively few competent research centers on magnetic properties of materials, heat management and recovery, and lighting. However, scale is a variable completely unrelated to how challenging the science is that bears on each of these subjects and to the potential economic importance of research results.

Society should seek to distribute the attention of its applied scientists and engineers across the full range of energy issues, from generation to end use, in a more balanced pattern. When for social reasons the R&D community is led to neglect important technical issues, the causes should be diagnosed and deliberate steps taken to redress the balance.

DOE's R&D programs tend to undervalue research on small-scale energy conversion. In particular, the Division of Basic Energy Sciences undervalues end-use technology. At the same time, the Office of Conservation is subject to steady pressure to prove the short-term applicability of its programs and does not benefit from the tolerance shown to the division's longer-term research.

An attempt should be made to infuse each of these two DOE units with the other's concerns. The refrigerator, air conditioner, home furnace and water heater, commercial cooker, ventilation fan, truck tire, automobile engine, blast furnace--each has received varying recognition from the science and engineering establishment as a system deserving dedicated attention of very talented people. Interesting problems in fluid mechanics, heat transfer, properties of materials, control theory, and catalysts surround each of these systems. An integrated approach is needed in which proper weight is given to the role of new science and engineering in transcending the current levels of performance of each of these systems. Improved communication and coordination with the Division of Basic Energy Sciences beyond that which already occurs with the Energy Conversion and Utilization (ECUT) program, should help the Office of Conservation improve its focus on the generic patterns of energy use systems.

TECHNOLOGY TRANSFER AND COST SHARING STRATEGIES

Planning for technology transfer should be an integral component of the multi-year planning process, but the MYP does not reflect this. Decisions related to project initiation, continuation, and phaseout should explicitly reflect criteria related to technology transfer possibilities and strategies.

Accelerating Commercial Adoption

Technology transfer is the process by which information acquired in a R&D program (i.e., the Office of Conservation) is adopted for use by either private industry or government agencies. Assuming that most worthwhile discoveries and developments in energy conservation research will eventually be made independent of the DOE, the principal purpose of federally supported R&D is to accelerate the introduction of new technologies into the marketplace. This is clearly recognized by the Office of Conservation (DOE, 1985, pp. 9, 10) which estimates the time-frame as about 10 years.

Since the incentive for federal investment in R&D is highly dependent on the speed with which discoveries can be adopted for use, research planning should logically include an optimum strategy for accelerating and ensuring adoption by U.S. users.

The optimum strategy will vary widely between projects, depending on the state of advancement of the research and the nature of the potential users. If the users are found in a fragmented industry with limited R&D and risk-taking capabilities, technology transfer will require a relatively large federal investment in development and risk sharing with either individual companies or with industry consortia, such as EPRI and GRI. The resources required for such programs can be substantial.

At the other extreme, users may be capable of quickly exploiting a new understanding or a new material coming from the research laboratory. Meetings and publications can accomplish the transfer of such information in a timely manner. In this case, a significant time advantage over foreign users may not be gained, especially if foreign R&D organizations are stronger than their U.S. counterparts.

An additional mode of transfer is within DOE, from a group carrying out basic or exploratory research to one whose mission is more developmental. While acceleration of technology transfer can involve significant allocation of resources, early completion of the transfer process can result in project terminations. This would free funds for new research programs.

In its National Energy Policy Plan (NEPP) DOE appears to have taken an unduly passive role in the acceleration of technology transfer (DOE, 1983). As quoted in the MYP DOE appears to discourage working with users to reduce the risks involved in adoption of new technologies that deviate significantly from standard practice (DOE, 1985, pp. 31, 32).

> The Administration does not support an emphasis on federal funding of large-scale conservation (demonstration) projects, or the implementation of federal regulations upon consumers and businesses to conserve energy according to federal mandate.

Large, federally funded demonstration programs carried out without significant commitment of financial and intellectual resources by potential users have a poor record. Effective technology transfer requires direct involvement by advocates of new technology in development and demonstration. DOE should actively pursue appropriately scaled demonstration projects, with an emphasis on private sector cost sharing, as an important strategy for the acceleration of technology transfer.

Private Sector Cost Sharing

The federal government can minimize its investment and accelerate technology transfer by getting private industry to share research costs. This is clearly recognized in the MYP FY 1987 (DOE, 1985, p. 37):

> There are two reasons why private sector cost sharing is sought and highly valued in the project evaluation process. First, and most obviously, is the financial leveraging of the public R&D investment dollar which private participation provides. Cost sharing typically ranges from 20 to 50 percent of the total project cost.
>
> Second, and more importantly, substantial private commitment to a project is viewed as independent confirmation that the proposed ideas are sound, that the federal project is not redundant of private sector work, and that the transfer to and adoption of the technology by industry will likely occur more smoothly if the R&D project is successful. Cost sharing of applied research is the type of private sector input most valued in ensuring the vitality and usefulness of the Conservation R&D programs.

The Office of Management and Budget Proposal

The issue of cost sharing has taken on a new sense of priority recently as a result of a proposal by the OMB (OMB, 1986). The issue is somewhat complex and has not been analyzed in depth by the committee.

The OMB draft contains a DOE analysis of the proposal in which many of the underlying assumptions are questioned and problems of a detailed and practical nature to the implementation of the policy are raised. For example, DOE points out that the proposal "does not fully recognize the extent of (current) private sector participation and cooperation in the development of R&D targets and current DOE program strategies." DOE describes in some detail the extensive private sector inputs into the multi-year planning process (DOE, 1985, pp. 56, 106, 136, 178, 207, 240).

In fact, cost sharing has been operational in the Office of Conservation. Research contracts with private industry or research institutions call for cost sharing, ranging up to 71 percent of the project costs. The exact percentage depends on perceived time to achieve payoff for the private sector participant. The OMB proposal poses a number of implications and problems for the Office of Conservation, some of which are discussed in the following sections.

Measurement of Cost Sharing

In principle, cost sharing is quantifiable, but existing measures are not very reliable. The amount officially reported may include the equipment, materials, travel, direct labor, and overhead costs of the company. Government audit procedures generally ensure that these and related costs are not overstated. The problem is that participating companies will often spend far in excess on the program than is required by the contract, so that the true costs are understated. There is no legal obligation to report such costs, as they are not germane to demonstrating compliance with a particular R&D contract.

DOE program managers believe that companies enter into cost sharing contracts as part of a larger corporate strategy to develop a technology of interest. Such strategies are proprietary and a company may wish to keep related costs hidden or secret, for good and valid business reasons.

There may be ways to approximate the actual corporate commitment to given technologies on a statistical basis, using survey techniques respecting proprietary data (see Chapter 4 recommendations on social science research). The Office of Conservation should study improved means for measuring and documenting the active level of corporate commitments to cost-shared programs.

Developing Targeted Cost Sharing Strategies

Cost sharing strategies are not spelled out by the MYP as part of the research strategy for individual programs. Such strategies need to be tailored to each program office. They should take into account:

- Time to expect commercial application,
- Degree and nature of risk,
- Nature of competition within the industry,
- Degree of fragmentation or consolidation of resources for R&D within the industry,
- The industry's history of R&D and technological change, and
- Foreign private and public sector arrangements in similar areas.

The OMB proposal has merit in that increased cost sharing would contribute to an improved process of technology transfer. Any policy to increase cost sharing, however, should not compromise standing policies to support high-risk and long-term R&D that, for various reasons, does not attract private sector commitment, i.e., long-term capital commitments and risks too high for a single firm to bear, benefits of the research not being appropriable by the investor, and related reasons (see NRC, 1986a for additional discussion of this issue).

A cost sharing policy should ensure that: (1) a careful implementation plan with strong private sector participation be prepared; (2) such a plan reflect variable cost sharing targets for short-, mid-, and long-term research (see Chapter 4, section on portfolio content); (3) the long-term portfolio of the Office of Conservation be protected and sustained at a reasonable level to be determined as part of the multi-year planning process; and (4) the policy be fine tuned to the characteristics of the sectors served by each of the four program offices as discussed in the following sections.

Planning for Technology Transfer

Both the buildings and industrial programs (DOE, 1985, pp. 60, 69) have technology transfer components and funds ($5.5 million and $1.5 million, respectively). In addition, much of the extensive private sector input (as described in DOE, 1985, pp. 56, 102, 136, 178, 207, 240) deals with technology transfer issues. However, the actual strategies for accelerating technology transfer by each program are not well developed.

Technology transfer could be substantially improved if the MYP presented research strategies that included the identification of partners to apply research results and a plan for gaining maximum commitment and participation of these partners. The strategic plans should seek to reduce the time between research and commercialization and to maximize use by U.S. companies. Implementation of any new cost-sharing policy should take place within the framework of a technology transfer strategy. It should not be done at the expense of a basic portfolio of needed long-term research.

DOE should actively develop improved strategies for technology transfer targeted to the user communities for each program. Applied research programs should assume from the beginning that these efforts will succeed and should lay the groundwork for optimum technology transfer.

The four programs differ substantially in the targeted users and, consequently, in the type of R&D undertaken. Brief comments on the technology transfer content of the individual plans of these program follows. In general, the MYP does not adequately discuss technology transfer strategies. Each program should fully develop and describe its respective strategy within the MYP.

Residential and Commercial Buildings

The buildings sector is the most fragmented and, for most applications, has the lowest private R&D and risk-taking capability of the sectors served by Office of Conservation programs. Technology transfer tops the discretionary project priority list with a recommended 1987 budget of $5.7 million, mostly focused on the education and information needs of builders, architects, manufacturers, educators, utilities, and local government (DOE, 1985, pp. 73, 92). Such an activity is clearly needed.

There is, however, little mention of a strategy for transfer of technology resulting from individual research programs. An example is fluorescent lights. The plan lists as an accomplishment, the improved efficiency of fluorescent lamps by nearly 35 percent (DOE, 1985, p. 48). This was achieved by combining the effects of both isotope enrichment and magnetic enhancement. The more detailed discussion of lighting research emphasizes the need for further research before improved fluorescent lamps are ready for commercial use (DOE, 1985, p. 66). There is no mention of a technology transfer strategy although claims indicate that the time may be ripe for closely coupled industrial involvement and cost sharing.

The community systems area, in contrast, emphasizes technology transfer, and the health-related studies appear to be in contact with appropriate groups.

Transportation

The engine and vehicle manufacturers are the principle users of DOE-sponsored research on energy conservation in transportation. Those most able to use research results already have good engineering and development capabilities and, in several cases, competent R&D organizations. The Office of Conservation emphasizes R&D relating to electric vehicles and advanced heat engines.

There is evidence of cost-shared activities on battery-powered vehicles in the programs of EPRI, DOE, and General Motors (GM) and possibly at the new Idaho National Energy Laboratory (INEL) facility. However, these programs are given rather low priority (15 and 16 out of 24) and the overall strategy for them is not clear (DOE, 1985, pp. 116, 118-120). There is some evidence that a van may be the first new electric vehicle to achieve commercial success. As such, it would provide an excellent test bed for new batteries and propulsion systems. The MYP should specifically mention a strategy for transferring results from the mandated electric vehicle program.

Research on ceramics for high temperature engines is a promising and highly competitive area. The new High Temperature Materials Laboratory at Oak Ridge, Tennessee appears to offer high potential research advances and for development of a technology transfer strategy that favors U.S. applications.

Industrial Programs

Here, the general strategy is stated to be negotiation of cost sharing arrangements and coordination with research consortia, such as GRI and EPRI (DOE, 1985, p. 125). Technology transfer is given first priority among discretionary projects. However, this $1.5 million per year effort is aimed primarily at information dissemination (DOE, 1985, pp. 153, 162). Most of the programs are of an engineering development nature and seem appropriate for direct industrial involvement at an early stage. The two congressionally mandated programs on thin strip casting appear to have industrial involvement, but the MYP presents no details (DOE, 1985, p. 159). (See NRC, 1985 for a detailed assessment of the industrial energy conservation programs.)

Energy Conversion and Utilization Technologies

The Energy Conversion and Utilization Technologies (ECUT) program seeks to expand the knowledge base to support initiatives in both DOE end-use conservation programs and the private sector. Transfer of research results to the private sector is accomplished through workshops, symposia, and, presumably, by publication in the open literature. Most of the work is fundamental research. Thus, the above mode of transfer seems appropriate, although some opportunities for cost sharing may exist. The projects sponsored by this program are more innovative and basic than those of the other programs. Therefore, cost sharing targets are expected to be lower than in the other programs.

Electric Energy Systems and Energy Storage Technology

Since publication of MYP FY 1987, these programs have been transferred from the Office of Conservation to the Office of Solar Energy (see NRC 1986b for a recent detailed critique of the Electric Energy Systems program).

Technology Transfer Practices in Other Countries

Several other countries place considerable emphasis on an R&D strategy that includes technology transfer and commercialization in carefully chosen areas (see Appendix A). Canada and Germany, for example, emphasize early identification of industrial partners with relatively little reliance on their national laboratories and an emphasis on cost sharing. The involved industrial group typically owns the patent rights if its share of the cost is more than 50 percent. Japan has a mixed strategy of supporting government laboratories through its Ministry of International Trade and Industry (MITI) while also encouraging formation of industrial consortia.

The Office of Conservation should continue to participate in international forums so it can monitor developments in other countries that could affect the MYP for technology transfer. Studies, such as the recent review of industrial energy conservation R&D in Europe (Hagler, Bailly and Company, 1985), and the information flow of energy conservation research in Japan (Hane, 1984), should be encouraged.

PLANNING METHODOLOGIES

Program Methodologies

The planning methodologies used by the four programs appear to relate only in a very general way to the hierarchy of guidance (see Chapter 2). The MYP lists various criteria for evaluating projects (DOE, 1985, pp. 70, 111, 151, 186, 220, 249) such as benefit-cost ratio, energy savings potential or alternate fuel capability, degree of technical risk, and appropriateness of federal funding. In addition various nonenergy criteria, such as national security, industrial competitiveness, and general societal needs such as health, environment, and reliability of electrical systems, are indicated.

However, there are many distinct differences in emphasis and approach in these criteria and the specific planning guidance reported by the programs (summarized in Tables C-9 and C-10). They vary, for example, in the method of calculating cost-benefit, the estimation of technical and market risk factors, assessment of industrial interest, technology transfer potential, and nonenergy benefits. In addition, at least qualitative differences exist in the assessment of the technical merits of ongoing projects and the role of this assessment in the assignment of priorities.

Two major adverse effects stem from these differences in planning methodologies and the lack of the Office of Conservation's internal coordination in the actual planning process on the overall R&D portfolio:

- There is no consistent way to ensure that the best mix of program content is achieved in the context of the overall objectives for energy conservation research.
- Project areas tend to overlap because of the independent planning procedures used by the four offices. Examples include battery and fuel cell development, combustion and thermal technology, catalysis, and advanced materials development.

These problems could be minimized by a consistent planning methodology and program coordination scheme. Appointment of a planning director, as previously indicated, would help coordinate plans among the four program offices throughout the year.

A single, rigid set of planning criteria cannot be uniformly applied because of the inherent technical differences in the programs. Moreover, each program may need to give different weights to various elements of a broad, office-wide set of planning criteria. This should not inhibit, however, the establishment of a well-defined, quantifiable, and consistent set of office-wide planning criteria as a basis for the development of individual program planning methodologies.

Strategic Planning Methodology

Attributes of a Methodology

Formal strategic planning methodologies can contribute significantly to the multi-year planning process. They can link the various components and increase the rigor of the planning process. Such models can be used to:

- Define and measure multiple goals and objectives within a hierarchical framework;
- Relate the various investment options to the multiple goals and objectives;
- Clarify uncertainties beyond the control of decision makers and planners;
- Analyze risks and benefits for various possible outcomes;
- Identify decision rules that improve the quality of decisions by, for example, maximizing or minimizing some variable or achieving some balance in the outcome while meeting specified constraints and criteria;
- Research decisions on contingency plans for wrong guesses and hedging strategies as insurance against adverse future developments; and,
- Evaluate constraints, such as mandated programs and budgetary restrictions.

There are many factors that will affect how the above points are quantified in actual planning. The Office of Conservation should explore possible approaches with the assistance of outside strategic planning expertise.

Some planning situations lend themselves to virtual complete quantification in which computers can carry out completely the instructions of planners or decision makers, for inventory control and routing for example. At the other extreme, situations such as international diplomacy, which cannot be quantified in a reliable manner, can be analyzed by using decision trees, for example, to map out alternative outcomes of policy options.

Application to the Multi-Year Planning Process

The multi-year planning process is a classic example of a strategic planning problem, which is amenable to the above modes of analysis. However, DOE's planning process does not use the formal, more quantifiable techniques that have been applied to many other public policy and planning situations (Stokey and Zeckhouser, 1978; Nesbitt et al., 1985, 1981; Bender, et al., 1981).

Many of the planning techniques described in these and other references were developed before the advent of modern large capacity storage and high-speed microcomputers with advanced ability to manage data bases. Current electronic spreadsheets, for example, can be used to specify any computation for any cell or group of cells in a matrix. Thus, state-of-the-art tools exist with which to approach the strategic planning problems of the Office of Conservation.

The current approach to multi-year planning can best be described as largely intuitive and qualitative. (See Energetics, 1985, for a recent description of one attempt to partially quantify the planning process for the industrial programs area; and Elliott, 1982, for an earlier attempt to develop a generic method for planning R&D for conservation and renewable energy.) This is neither inappropriate nor does it necessarily lead to wrong results. No strategic planning methodology can serve as a substitute for the intuition and professional judgment of experienced research managers.

However, an appropriately designed and sensitively applied quantitative methodology can enhance the quality of planning decisions, increase the level of confidence in decision making, and help to communicate this confidence to higher-level decision makers. The attempt of the industrial program office (Energetics, 1985) is an excellent start in this direction; additional efforts should be encouraged.

Procedure for Exploring Strategic Planning Approaches

Clearly, the introduction of practical and useful advanced planning methodologies is not a trivial task. It needs to be done in the context of planning for the multi-year planning process itself. The following procedure could be used to ensure that the particular methodology chosen is compatible with the needs of the Office of Conservation and practical in terms of application:

- Design a methodology specifically keyed to the hierarchy of guidance (see Chapter 2) and describe it in detail.
- Have each person who participates in the multi-year planning process evaluate and help design the methodologies. Criteria may include: ability to understand the method, reasonableness of data requirements, ease of use, agreement with the cause and effect relationships represented, agreement with optimization or decision-balancing procedures, time and effort required, and other factors.

- Fine-tune the methodology in response to the above review.
- Test the methodology, if possible, without interfering with the current multi-year planning process.

Outside expertise can be engaged to study the multi-year planning process, design alternative methodologies, and assist with the other steps. However, such methodologies can only be successfully introduced through systematic, in-house efforts involving all relevant programs.

The Office of Conservation would benefit from such a strategic planning methodology by an increased ability to:

- Respond to hierarchy of planning guidance by measuring the degree to which the goals of the Office of Conservation and its programs are met;
- Map out decision trees showing the implications of planning decisions as a function of future unknowns, such as R&D outcomes, price of oil, state of the economy, and other factors deemed relevant by planners;
- Accommodate the results of ongoing program assessments and technology reviews into the planning process;
- Rapidly analyze multiple scenarios of decisions and of future uncertainties including an appropriate measure of risk; and,
- Communicate the results of scenario analysis to decision makers in a readily understood format.

Achieving a higher degree of quantification and decision documentation is a worthwhile goal of the planning process. However, the ability to actually advance in this direction is itself subject to uncertainty. It is by no means certain that a given attempt to introduce formal strategic planning will actually produce useful results. The quality of outcome will be a function of the skills of the designer of the methodology, the skills and commitment of the office planning personnel, the quality of management guidance, and the level of resources committed to the effort.

Therefore, the Office of Conservation should initiate a study design to explore formal strategic planning issues. This could be done by a person or firm experienced in strategic planning in various institutional settings. Such an exercise should precede any further steps in this direction. The study design should lay out various options and consider the cost of their implementation to the Office of Conservation. This will provide information that will help guide the move toward a more rigorous strategic planning process for the MYP.

4

THE PORTFOLIO

OVERVIEW

This chapter examines the portfolio presented in the multi-year plan for fiscal year 1987 (MYP FY 1987). The first section is a critique of the MYP's view of portfolio balance and diversity. The committee finds that the measures of "balance and diversity" used in the MYP do not correspond in a direct way to criteria set forth in the hierarchy of planning guidance. The committee recommends that portfolio composition be described in a manner that relates to that hierarchy, and that "time to commercialization" be used as an additional parameter for classifying projects. By relating portfolio analysis to the hierarchy of guidance as reformulated in Chapter 2, the intended benefits of a given portfolio can be more readily understood and displayed.

The second section suggests four additional research areas for the portfolio. Research and development (R&D) for government facilities is indicated as an area with a very high potential for short-term savings. Research in the area of social sciences to increase the understanding of end-use behavior is also indicated as an area with high energy conservation leverage. Research on energy efficient manufactured housing is identified as an excellent opportunity for the Buildings and Community Energy Systems Program. Finally, the committee suggests that research on strategic planning methodologies for the office itself, be included as a program activity. For additional suggestions on candidate areas for the portfolio, the reader is referred to a recent Energy Engineering Board report (NRC, 1986a) that was commissioned by the Energy Conversion and Utilization Technologies (ECUT) program.

PORTFOLIO BALANCE AND DIVERSITY

The committee has been charged to "examine and critique current (and implicitly cumulative) program emphasis, balance, and diversity in relation to long-term technological needs and opportunities for energy conservation" (see Preface). The following critique is based upon the portfolio analysis provided by Chapter 1 of the MYP. The committee does not attempt to replan the portfolio. The major findings are:

- The portfolio does not relate directly to the statements of the mission, objectives, or strategy of the Office of Conservation.
- The portfolio analysis appears to apply criteria after an ad hoc planning process rather than as an a priori set of targets for a more analytically based planning process.
- The mission, objectives, and strategy statements that guide the portfolio selection process need to be reformulated (see Chapter 2) so that quantifiable measures of portfolio balance and diversity can be applied.

These observations are supported by the following discussions.

General Descriptors

The MYP classifies the research projects in the proposed FY 1987 portfolio in several ways. Figure 4-1 shows that about three-quarters of the budget (for FY 1987 alone, not the cumulative five-year projection) is for technology R&D, while Figure 4-2 shows the distribution of the balance of the portfolio. Figure 4-3 shows how the technology R&D portfolio is distributed, indicating a heavy weighing toward basic, applied, and exploratory R&D. Figure 4-4 shows how the overall portfolio is distributed according to technical discipline, Figure 4-5 by physical phenomena, and Figure 4-6 by materials.

The above are interesting ways of classifying the portfolio, but no relationship is shown between the respective distributions and the satisfaction of mission, objectives, or strategy statements. Are these distributions the circumstantial results of planning and thus only of academic interest? Or are they quantitative a priori guidelines for ensuring that the portfolio meets desired, mission-related criteria in terms of objectives and strategies? The use of such charts in the multi-year planning document needs to be rationalized and related, at least qualitatively, to the hierarchy of planning guidance. The cited figures do not meet this criterion.

Acceleration Period

The next illustration begins to bear some relationship to concrete planning targets. Figure 4-7 shows the distribution by "acceleration period." This begins to be useful, but begs for additional information and insight. With respect to the figure itself:

- What are the respective baselines against which the acceleration period is measured?
- What is the evidence for the achievement of such claims of acceleration?

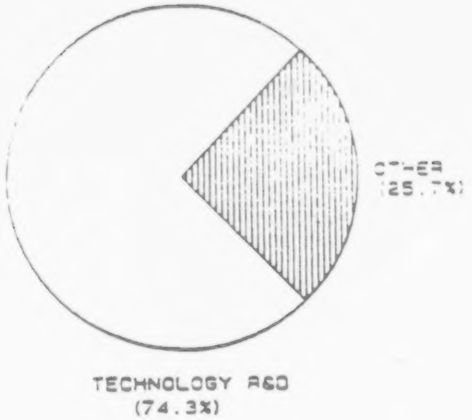

FIGURE 4-1 Portfolio composition by project category.

SOURCE: Department of Energy

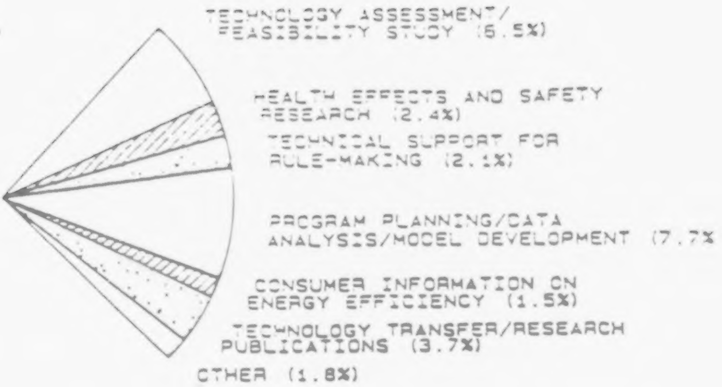

FIGURE 4-2 Portfolio composition of "other" or non-technology components (parts sum to 25.7 percent).

SOURCE: Department of Energy

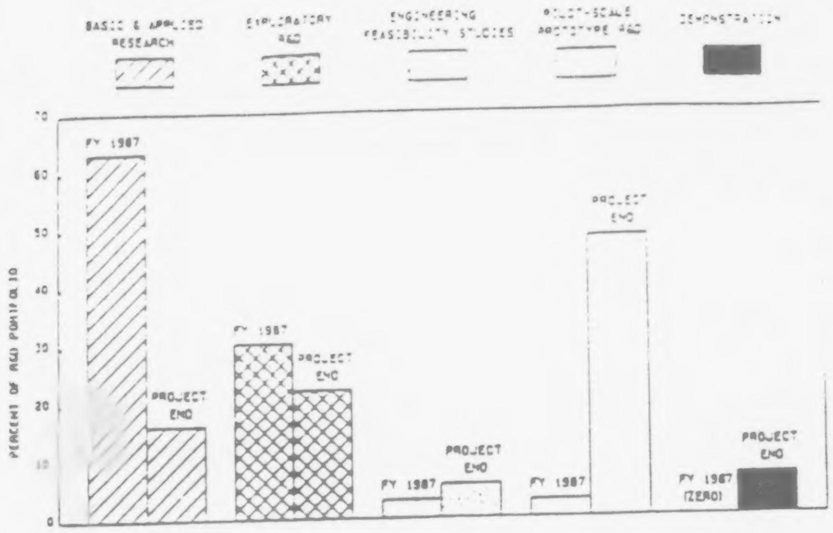

FIGURE 4-3 Composition of technology R&D component by phase of research.

SOURCE: Department of Energy

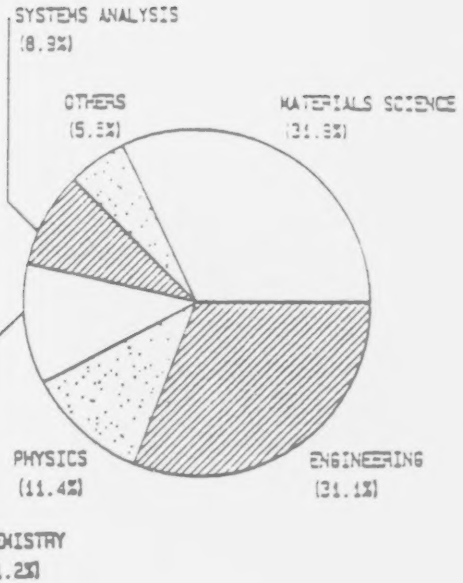

FIGURE 4-4 Portfolio composition by technical discipline.

SOURCE: Department of Energy

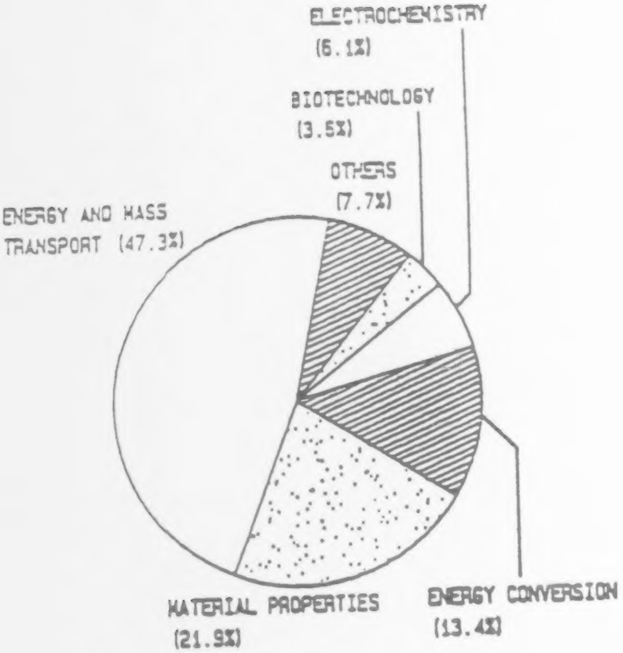

FIGURE 4-5 Portfolio composition by physical phenomena.

SOURCE: Department of Energy

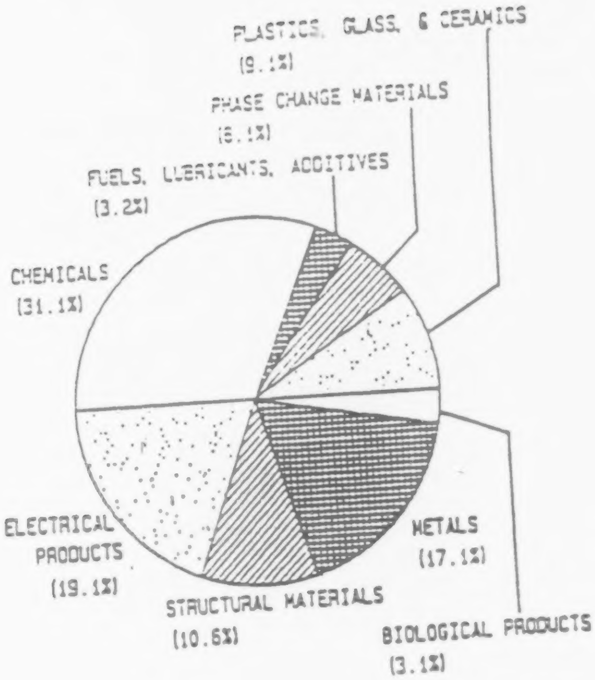

FIGURE 4-6 Portfolio composition by materials.

SOURCE: Department of Energy

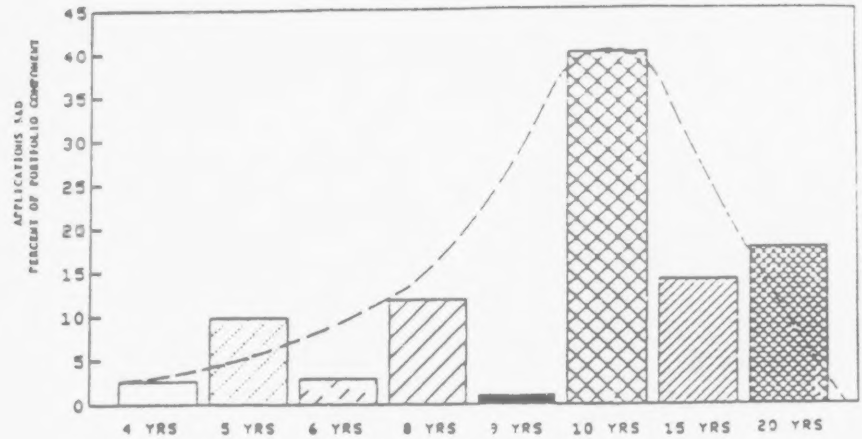

FIGURE 4-7 Portfolio composition of applications oriented R&D by estimated project acceleration period.

SOURCE: Department of Energy

The MYP further reports a mean acceleration value of 11.3 years, stating that this is "confirmation of the appropriate federal role--not too near, yet not too far away" (DOE, 1985, p. 10). This is vague. The relationship to specific statements of federal purpose in the plan is not at all clear. Thus, the presentation detracts from understanding how the portfolio actually meets stated goals.

The following recommendations are made with respect to acceleration period:

- First, classify the portfolio according to "time to commercial use," as recommended earlier. This should be done a priori so that the planning process works toward a specific set of targets, which may differ among the four programs. In this way, appropriate planning baselines are established.
- Then, within each category above, classify projects by acceleration period.
- Display the results of both analyses independently in the MYP and explain why the distributions may differ among the programs.

Benefits of Portfolio

Figure 4-8 shows the intended impact of the portfolio on fuel use and substitutions. Figure 4-9 shows other energy-related benefits, and Figure 4-10 shows major nonenergy benefits.

The problem here is that the benefits displayed do not adequately relate to the statements of mission and objectives. For these displays to be meaningful, they must bear a more direct relationship to explicit program goals. Part of the problem is that the hierarchy of planning guidance itself is somewhat diffuse (see Chapter 2).

Referring to the reformulated "objectives" in Chapter 2, Figure 4-8 can be considered an intermediate step in an analysis of how the portfolio contributes to energy security using indices such as "years of assured supply," or "relative dependence" (i.e., the ratio of imported oil over total energy demand), within an appropriate planning scenario as a baseline. Figure 4-9 has little value, but may be an intermediate product in showing how the portfolio meets the objectives of energy security and mitigation of adverse environmental effects. Figure 4-10 is actually misleading because it does not account for the multiple benefits in any given program. It is based only on the leading benefit of each program and does not meaningfully integrate the benefits expected from the portfolio as a whole.

The portfolio analysis should be further developed by scoring each project according to the overall objectives of the Office of Conservation. To the extent possible, such scoring should be quantitative and ultimately grounded on the reformulated mission statement in terms of market potential and impact in both energy and economic terms.

The intended or target benefits of the portfolio should not be an arbitrary result of an ad hoc planning process. This is the impression given by the current MYP. Rather, some process of analysis should be applied to create portfolio targets as a baseline for each of the four programs.

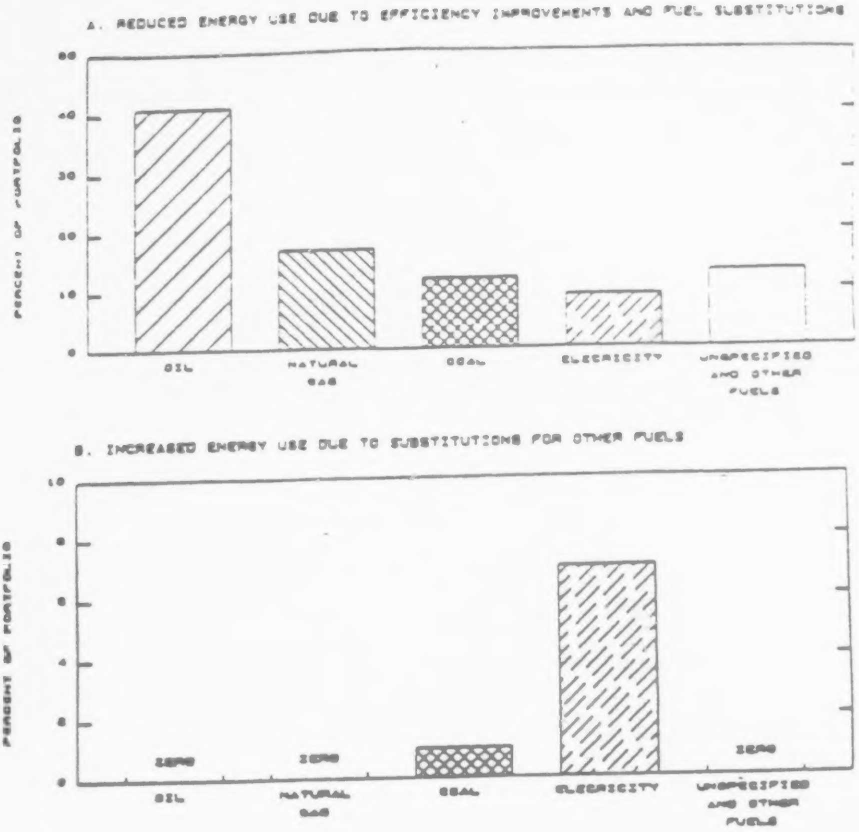

FIGURE 4-8 Portfolio composition by type of intended energy effect.

SOURCE: Department of Energy

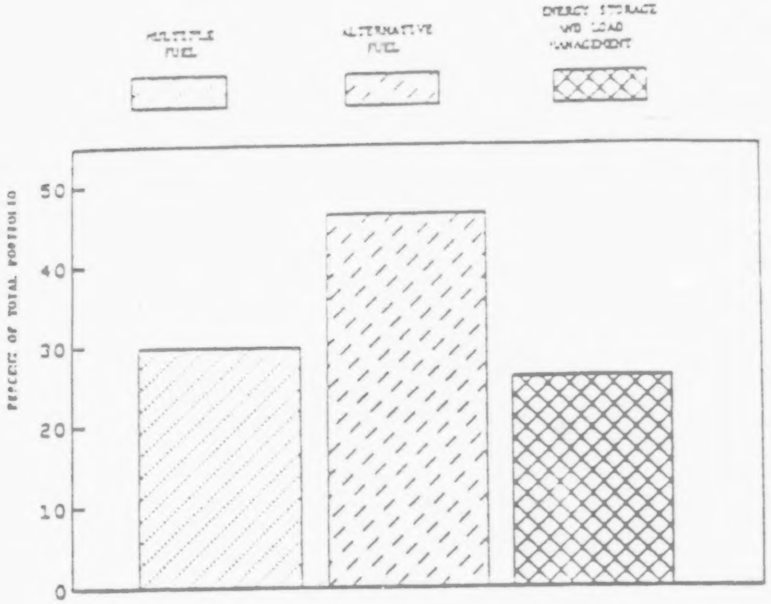

FIGURE 4-9 Non-energy benefits.

SOURCE: Department of Energy

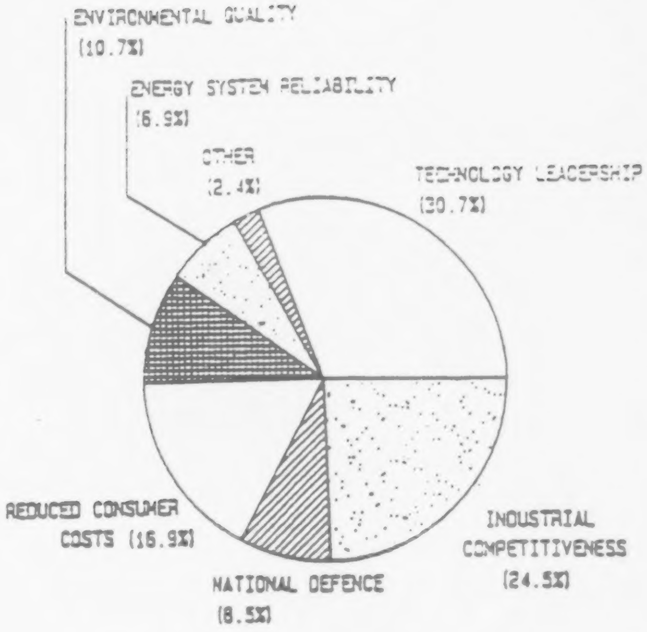

FIGURE 4-10 Non-energy benefits.

SOURCE: Department of Energy

This is not to suggest that a close-ended methodology be created and adhered to in any strict sense. Ultimately, sound decisions on each project in the portfolio depend upon the personal experience and judgment of the program managers. Additional quantification and the use of analytical methodologies (see Chapter 3) are merely tools to ultimately guide executive-level planning decisions. Planners have to know the limits of any methodology, use it flexibly, and take into account a range of factors that necessarily lie outside of the formal analysis. In this sense, the Office of Conservation should be more analytical in portfolio planning, using an appropriate methodology as a tool. The purpose is to relate project decisions to the hierarchy of guidance as directly as possible.

The setting of a priori quantitative criteria for the portfolio should be regarded as a working tool, using the following procedure: (1) start with a set of a priori portfolio targets that relate as directly as possible to the mission, objectives, and strategies; (2) work through the planning process, using the appropriate mix of methodologies and professional judgment of the planners; (3) measure each candidate portfolio against the original targets; and (4) adjust project decisions as appropriate.

Time to Commercial Application and Cost Sharing

Each project in the portfolio should be classified according to the expected time to commercial application: short-term (1-3 years), medium-term (3-10 years), and long-term (more than 10 years). As a starting point, one may consider balancing the portfolio equally among the three classes.

Cost sharing targets should be established within each of the classes. These are expected to differ for each of the four program offices. For example, a program may set the following cost sharing targets: short-term portfolio, 40-70 percent; mid-term, 30-50 percent; and long-term, 10 percent or less. Assuming that the portfolio is uniformly distributed among the three categories, on balance this example would result in an overall portfolio cost sharing of about 33 percent, an increase over the current level.

The purpose of planning in this manner is to ensure that cost sharing targets are realistically set in a way that industry will respond to, and that the Office of Conservation can actually implement. It is essential to first classify by short, medium, and long range to ensure that the longer-term, higher-risk projects are not squeezed out by a priori cost sharing targets.

PORTFOLIO CONTENT

In terms of new areas, the Office of Conservation should consider sponsoring research on government facilities, the social sciences, energy-efficient factory-built housing, and appropriate strategic planning methodologies. The first three are discussed in the following section and the latter has already been covered in some detail in Chapter 3.

Research for Government Facilities

> The U.S. government is the nation's largest single user of energy, accounting for some 2 percent of the fuel used in 1981. The Department of Defense (DOD) is the dominant user representing 82 percent of the energy consumed. In FY 1981, the DOD spent $10.7 billion for direct fuel costs alone (ERAB, 1983a).

Table 4-1 shows the Energy Research Advisory Board's (ERAB) analysis of federal energy use by agency. These energy costs are an obvious and significant component of the federal budget. A less obvious component is the aggregate of energy costs, paid indirectly, in welfare assistance to compensate for utility bills in nongovernment buildings, in the fuel component of airfares of government employees traveling on business, and in the energy component of government purchases of paper, cement, and macadam, among other products. Estimating the energy consumption of the federal government in a comprehensive manner, as well as the budget implications, is not an easy task, even conceptually. But it is possible with some concerted effort to identify a few of the important terms, as ERAB has done.

In an age of heightened concern for reducing federal budget deficits a coherent strategy could cut those particular expenditures related to energy. Energy expenditures in the U.S. economy as a whole represent about 12 percent of the total gross national product (GNP), a fraction that in fact is falling gradually. If the energy fraction in the federal budget is the same, the direct and indirect energy costs would total more than $100 billion.

A coherent strategy to address this massive energy consumption is needed. It should have both a short- and long-term component, and address all of the relevant end-use areas.

It is not clear why it has been so difficult to associate the Office of Conservation with this important agenda given the findings and recommendations of DOE's own review of this issue more than three years ago (ERAB, 1983a). Nowhere else in government is there a competing center of energy conservation expertise. Appropriate coordinating groups within each of the other departments and agencies should be established to advise and coordinate energy conservation research programs for federal operations as part of the multi-year planning process.

TABLE 4-1 Percentage of Federal Energy Use by Agency, FY 1981 (BTUs × 10^9)

Agency/ Department	Buildings & Facilities	Vehicles & Equipment	Total	Percent of Total	Cumulative Total Percent
Defense	558,200.0	897,263.1	1,455,463.1	82.04	
Energy	57,145.5	28,623.5	85,769.0*	4.84	86.88
Postal	40,228.6	10,698.1	50,926.7	2.87	89.75
GSA	39,064.6	130.8	19,195.4	2.21	91.96
VA	36,913.3	571.2	37,848.5	2.11	94.07
Transportation	17,032.0	11,061.0	28,093.0	1.58	95.65
NASA	19,412.0	1,818.0	21,120.0	1.2	96.85
Interior	7,592.5	3,088.2	10,680.7	0.60	97.45
Agriculture	6,488.9	4,579.7	11,068.6	0.62	98.07
HHS	10,030.3	554.1	10,584.4	0.60	98.67
Justice	5,213.4	1,785.8	6,999.2	0.40	99.07
Treasury	2,062.9	1,925.5	3,988.4	0.22	99.29
Commerce	2,352.4	1,098.0	3,450.4	0.19	99.48
Labor	2,595.2	290.7	2,885.9	0.16	99.64
TVA	948.7	1,448.3	2,397.0	0.14	99.78
Panama Canal	829.9	727.2	1,557.1	0.09	99.87
EPA	1,234.6	184.0	1,418.6	0.08	99.95
Other	508.6	308.9	897.5	0.05	100.00
Subtotal(nondefense)	249,653.4	68,972.7	318,626.4	100.0	
Subtotal(defense)	558,200.0	897,263.1	1,455,463.1		
Total**	807,853.4	966,235.8	1,774,089.5		

*Includes electricity used in uranium enrichment. Some of the cost is recovered by the sale of the enriched uranium to the private sector and other governments.

**Totals do not include energy use in federally funded, but not federally managed housing.

SOURCE: Energy Research Advisory Board (ERAB, 1983a)

The Office of Conservation should develop a portfolio of projects specifically targeted at energy efficiency in federal buildings, vehicle fleets, and other government facilities. This component of the portfolio would be short-term, low-risk, and high-payoff.

To create the institutional mechanisms for such a portfolio, the Office of Conservation might create a federal energy conservation program with a significant budget of its own (say, $100 million). Other federal agencies could be invited to submit proposals for research projects in much the same way that private sector entities do. Cost sharing for planning, feasibility studies, pilot programs, and demonstrations, all of which result in reduced overhead budgets for federal agencies through energy conservation, should be encouraged.

Social Science Research

For reasons inadequately stated in DOE publications, such as the MYP, research on energy conservation has generally excluded the social sciences. This is especially remarkable as the bulk of improvements in efficiency of energy use has ultimately and necessarily come from the demand response of energy users: industrial, commercial, and residential. Increasing the ratio of productivity to energy input clearly requires technology (equipment, facilities, and processes) to implement intentions.

In this marriage of motivation with equipment, R&D efforts have been directed overwhelmingly at the hardware side. Planners have assumed that once the hardware was available economic self-interest would lead to technology acquisition and efficient operation. This is only partly true. The housing industry stands as a glaring example of the deficiency of that assumption. Houses today are generally built as if energy was available at a fraction of today's price, although there is a much of new energy-efficient technology available for building designs, materials, and electrical and mechanical systems. What are the impediments to translating this newly found knowledge into consumer demand? What linkages are missing? What institutions stand in the way and what new ones might be needed?

A recent report by the Committee on Behavioral and Social Aspects of Energy Conservation of the National Research Council (NRC, 1986c) explored some of these issues in depth, and it identified several areas of inquiry that appear fruitful. Answers to the questions posed by that report would help policymakers, vendors, and owners make more informed decisions leading to energy conservation. They would also help the Office of Conservation design its own research portfolio. Table 4-2 shows some suggested areas for social science research on energy conservation.

The NRC report also explores methods for answering questions that merit the attention of the Office of Conservation in considering the inclusion of a social science research component in its portfolio. A pilot program of modest proportion should be started to at least probe the social science R&D needs and the potential ways of meeting them. Such expenditure targeted at selected areas of ignorance in individual

TABLE 4-2 Recommended Agenda of Social Science Research for Energy Conservation

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Questions Related to the Design of Information Programs

- How can a program be designed so that the information it offers is used?
- How can a program be designed to spread information widely?
- How can the effects of a program be forecast?
- How can the effects of a program be assessed accurately?
- To what can program effects be attributed?

Questions Related to the Design of Incentive Programs

- How does investment change as a function of the size of an incentive?
- How does investment depend on the type of incentive offered?
- What programmatic factors affect consumers' use of incentives?
- How much investment would have occurred without the stimulus of a incentive?
- To what extent does an incentive increase the pace of an investment?

Questions Related to the Design of Standards

- Under what conditions does energy efficiency influence consumers' purchases?
- How might alternatives to standards, such as appliance labels or energy ratings for buildings, make energy efficiency a prominent consideration in purchase decisions?
- How is the importance of energy efficiency in purchase decisions affected by the circumstances and purposes surrounding the purchase?
- In the absence of standards, how do manufacturers, builders, and others make choices?

Questions Related to the Design of Technological R&D

- Which energy-efficient building technologies are most likely to be accepted readily in the market?
- How can reliable estimates of energy savings be developed for new technologies?

SOURCE: NRC, 1986c.

and corporate behavior could reveal insights that can yield important and early directions for public policy. It could help to justify or redirect technology research that may be based on incorrect assumptions about market and social behavior.

Research on Energy Efficient Factory-Built Housing

The following considerations support the need for a program to promote energy-efficient factory-built housing:

- Homes are one of the largest consumers of energy in the United States and a sector in which considerable conservation is possible.
- The United States may soon experience foreign (Japanese and Scandinavian) competition for the U.S. housing market.
- Producing affordable, energy-efficient factory-built homes (not mobile homes) could lead to an increase in market competitiveness at home and abroad (it opens the possibility of world markets).
- The U.S. home building industry is exceedingly fragmented and lacks the resources to do sufficient levels of research. (By contrast, the fourth largest Japanese home builder is larger than the largest U.S. home builder even though their annual market for new homes is only a bit more than half that of the U.S. new homes market.)
- The development of manufactured home industries in Japan and Scandinavia have required the integration of design, marketing, production, financial, labor, and code research, which is beyond the scope of any single U.S. company.

Therefore, a project involving research on energy efficient factory-built housing should be initiated. Additional considerations on energy efficient research opportunities related to housing and other structures are contained in a recent review of energy research at the schools of architecture (Architectural Research Center's Concorcium, 1986).

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APPENDIX A
AGENDA FOR THE COMMITTEE'S ROUNDTABLE

A-I Program

A-II Panelists and Sessions

A-III Issues Guide

APPENDIX A-1

ENERGY ENGINEERING BOARD
ENERGY CONSERVATION RESEARCH ROUNDTABLE
National Academy of Sciences
Joseph Henry Building
2100 Pennsylvania Avenue, N.W.
Room 451
Washington, D.C. 20418

December 4-5, 1985

8:30 - 4:30 p.m. Wednesday
8:30 - 6:00 p.m. Thursday

PROGRAM

WEDNESDAY, DECEMBER 4, 1985

8:30 - 8:35 **WELCOME ADDRESS**
Dennis F. Miller, Executive Director
Energy Engineering Board

8:35 - 8:40 **INTRODUCTION TO THE ROUNDTABLE**
William R. Gould
Chairman, Committee on Energy Conservation Research

8:40 - 9:00 **ENERGY CONSERVATION R&D OVERVIEW**
Alan J. Streb, Deputy Assistant Secretary for Conservation, Department of Energy
Robert Marlay, Executive Assistant for Conservation, Department of Energy

SESSION I
Overview and Planning Context

9:00 - 10:30 **A. Views on the Government Budget Process**
Moderator: Donald Prowler
Rapporteur: Milton Pikarsky

10:30 -10:45 BREAK

10:45 - 12:15 B. Views of Government Energy Advisors and Analysts

Moderator: Milton Pikarsky
Rapporteur: Donald Prowler

12:15 - 1:00 LUNCHEON (Buffet)

SESSION II
Energy Conservation R&D in Other Countries.

1:00 - 4:30 A. Other Country Needs and R&D Priorites: Industrial, Transportation, Buildings, Electric Systems. (Focus on long-term innovative R&D).

2:15 - 3:15 o Institutions: Research Centers, Government Private Sector, Non Profit. (Focus on how long-term R&D programs are financed and organized).

3:15 - 4:30 o Decision Processes: Long-Term Planning (Focus on who defines long-term plans, and how policy support is obtained).
Moderator: Elias Gyftopoulos
Rapporteur: Hans Landsberg

6:30 - 7:00 **RECEPTION**

7:00 - 9:00 **DINNER:**

Speaker: The Honorable George Brown (D-Calif.)
Senior Member of the House of Representatives
Committee on Science and Technology
Place: National Academy of Sciences
2101 Constitution Avenue, N.W.
Washington, D.C.
Great Hall and Auditorium Gallery

THURSDAY, DECEMBER 5, 1985

SESSION III
Government Energy Conservation R&D Planning and Priorities.

8:30 - 8:35 **INTRODUCTION:** Anthony Finizza

8:35 - 10:30 A. DOE's Multi-Year Planning Process - Critique of Missions, Results, Management, Resources
Moderator: Jeremy Shapiro
Rapporteur: Elias Gyftopoulos

11:00 - 11:15 BREAK

SESSION IV
The Role of the National Laboratories and Major Institutional Contractors.

11:15 - 12:00 A. Definition of Missions
Moderator: Thomas S. Tenforde
Rapporteur: James C. Holzwarth

12:00 - 12:45 B. Participation in Multi-Year Plan
Moderator: James C. Holzwarth
Rapporteur: Thomas S. Tenforde

12:45 - 1:45 LUNCHEON

SESSION V
Views of Other Organizations.

1:15 - 2:30 A. Government
Moderator: John P. Longwell
Rapporteur: Gregory Zeikus

2:30 - 3:30 B. Non-Government
Moderator: Gregory Zeikus
Rapporteur: Robert Socolow

3:30 - 3:45 BREAK

3:45 - 5:30 SESSION VI
Committee Views and Perspectives (CLOSED SESSION)
Moderator: Anthony Finizza

APPENDIX A-II
PANELISTS AND DESIGNATED SESSIONS
FOR THE
COMMITTEE ON ENERGY CONSERVATION RESEARCH ROUNDTABLE

SESSION I

Overview Planning Context

A. Views on the Government Budget Process

NAME	ORGANIZATION
Alan Streb	Department of Energy
William T. Harvey	House Science and Technology Committee
Tom Price*	Ex Office of Science and Technology Policy, currently an energy lobbyist
Ronald Williams	House Science and Technology Committee

B. Views of the Government Energy Advisors and Analysts

Alan Streb	Department of Energy
Tom Sheahen	Energy Research Advisory Board
Peter Blair	Office of Technology Assessment

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*Guest

B. Views of the Government Policy Community (cont'd.)

Fred Sissine	Congressional Research Service
David Bodde	Congressional Budget Office
Roy Kirk*	General Accounting Office

SESSION II

Energy Conservation R&D in Other Countries

Dr. Albert Strub	Belgium, Commission of the European Communities, Non-Nuclear Energy Research
Dr. Peter Lumb	Canada, Department of Energy, Mines & Resources - Office of Energy Research and Development
Mr. Flemming Oester	Denmark, Risoe National Laboratory, Executive Assistant
Dr. Maurice Clavernie	France, Scientific Council, French Agency for Energy Conservation
Dr. Knute Bauer	Germany, Ministry for Research & Technology, Division of Biology Ecology and Non-Nuclear Energy
Dr. Carl Andreen	Sweden, Swedish National Board for Technological Development Head, Energy Technology Department.

SESSION II (cont'd.)

Energy Conservation R&D in Other Countries

Dr. R. G. S. Skipper	United Kingdom, Department of Energy, Energy Technology Division, Deputy Chief Scientific Officer
Dr. Katsuyuki Uesugi*	Japan, MITI, New Energy Development Organization
Dr. Eric Willis*	Ex International Energy Agency Director for Research and Development

SESSION III

Energy Conservation R&D Planning and Priorities

NAME	ORGANIZATION
Robert Marlay	Department of Energy
John P. Millhone	Department of Energy, Buildings
John S. Brogan	Department of Energy, Energy Systems
Melvin H. Chiogioji	Department of Energy, Transportation
William B. Williams	Department of Energy, Industrial Energy
John R. Rossmessl*	Department of Energy, Industrial Energy
Kenneth Friedman*	Department of Energy, Electric and Hybrid Propulsion

SESSION III (cont'd.)

Energy Conservation R&D Planning and Priorities

Philip Patterson*	Department of Energy, Transportation
Harvey Major*	Department of Energy
Fred Abel*	Department of Energy, Buildings and Community Systems

SESSION IV

The Role of the National and other Government Laboratories

NAME	ORGANIZATION
Arthur Rosenfeld	Lawrence Berkeley Labs
Thomas O'Hare	Brookhaven
William Fulkerson	Oak Ridge
Martin Bernard	Argonne
Danny Hartley	Sandia
Jim Hill	National Bureau of Standards
John Michel*	Oak Ridge

SESSION V

Views of Other Organizations

A. Government

NAME	ORGANIZATION
Walter E. Myers	Bonneville Power Administration
Peter House	National Science Foundation

SESSION V (cont.d)

Views of Other Organizations

A. Government

Robert Groberg	Housing and Urban Development
Alfred Lindsey	Environmental Protection Agency
Richard Donaghy	U.S. Army Construction

B. Non-Government

NAME	ORGANIZATION
Fritz Kalhammer	Electric Power Research Institute
Myron Gottlieb	Gas Research Institute
Marc Ross	University of Michigan, Ann Arbor, Michigan
Alan Miller	World Resource Institute
John B. Dicks, Jr.	American Society of Mechanical Engineers
Richard Eckfield*	North American District Heating and Cooling Institute
William Draper	Institute for Electrical and Electronic Engineers

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*Guest

APPENDIX A-III
ENERGY ENGINEERING BOARD

COMMITTEE ON ENERGY CONSERVATION RESEARCH
ROUNDTABLE

ISSUES GUIDE

SESSION I Overview and Planning Context

PURPOSE: To help the committee understand the larger context within which the multi-year plan is formulated and to understand the budget process.

IA. Views on the Government Budget Process

IB. Views of Government Energy Advisors and Analysts

Overview Issues

1. What do you think of the goals and objectives of the DOE/OEC multi-year plan.
2. What are your views of the institutional options for the research.

The Influence of DOE's Multi-Year Plan.

1. What are your views of the multi-year plan? What role does it play in decision making?
2. What are the strengths and weaknesses of the plan in terms of its presentation, quality of information, relevancy to the decision maker, etc.?

SESSION II Energy Conservation R&D in Other Countries.

PURPOSE: To help the committee enlarge its view of energy conservation R&D by reference to the planning experience of other countries.

1. What do you see as your country's most critical long-term energy problems?
2. How are national R&D needs in energy efficiency identified?

SESSION II (cont'd.)

Energy Conservation R&D in Other Countries.

3. How are goals (short- and long-term) for energy efficiency identified, agreed upon, and implemented?

4. Describe the program development and planning process in your country in terms of:

    a. What elements make an input and which are excluded?
    b. Who makes the choices at what levels of government (i.e. local and regional governments).

5. Describe the major features of your country's energy efficiency R&D, including a budgetary overview.

6. Is there a multi-year planning process that defines the energy conservation R&D portfolio? Please describe the major elements.

7. Is the national effort adequate? What else is needed?

8. How important is a continuing government role in energy conservation in R&D? To what extent is your private sector capable of pursuing energy conservation R&D on its own?

9. In what areas have government-private sector partnerships been critical to the success of research and development programs, or even to the ability to conduct such programs?

SESSION III

Government Conservation R&D Planning and Priorities.

PURPOSE:

To help the committee understand how the Office of Conservation formulates the multi-year plan, and works with the energy community at large.

SESSION III Government Conservation R&D Planning and Priorities. (cont'd.)

IIIA. DOE's Multi-Year Planning Process - Critique of Missions, Results, Management, Resources.

IIIB. Suggestions for Improved Coordination and Effectiveness.

1. What is the process by which programmatic objectives are set within the Office of Conservation? Is there sufficient input to this process by other organizations.

2. What are the limitations in the definition of goals? Can you clarify the hierarchy of goals?

3. Energy consumption per capita in the U.S. has declined significantly since the oil crises of the 1970s. Do you believe that we have reached a point of seriously diminished returns from conservation research? If not, what are the potential conservation areas where we can still do much better?

4. Recognizing the coincidence of objectives between conservation R&D and other government sponsored research, how do you define and coordinate your work to prevent duplication of effort?

5. DOE and other government activities in energy conservation are intended to foster research and development efforts in conservation devices for which the outcomes are too risky, or that would take too long for private industry. To what extent has this goal been realized?

6. How effective do you judge the technology transfer of conservation devices developed experimentally in universities and the national laboratories to practical implementation and use in private industries?

7. To what extent are conservation efforts in the U.S. coordinated with similar efforts in the rest of the world? To what extent are energy researchers in the U.S. aware of developments abroad?

8. In which energy consumption areas are conservation and environmental protection considerations most closely linked?

SESSION IV — The Role of the National Laboratories and Major Institutional Contractors.

PURPOSE: To help the committee understand the role of the national laboratories in formulating or influencing the multi-year plan.

1. What input have the national laboratories had to DOE's energy conservation R&D planning and priority setting?

2. What interactions have the national laboratories had with other organizations planning, performing, or using the results of energy conservation R&D, including other national laboratories?

SESSION V — Views of Other Organizations

PURPOSE: To help the committee understand the views of a variety of organizations that may have independent views on various aspects of the multi-year plan.

VA. Government

VB. Non-Government

1. What do you see as the country's most critical long-term energy problems?

VB. Non-Government (cont'd.)

2. What kind of long-term energy conservation R&D efforts would you suggest are in the national interest?

3. To what extent is the private sector carrying out such R&D? What are the major gaps? Why do these gaps exist?

4. What changes would help accomplish the R&D you feel is essential to the national interest.

5. What role should the Office of Conservation play?

6. How can the Office of Conservation improve its multi-year planning process?

7. To what extent is your organization a resource that can contribute to the multi-year planning process? What specific suggestions do you have for involving your organization?

APPENDIX B

LITERATURE ON ENERGY CONSERVATION RESEARCH

There is a considerable literature on the subject of energy conservation research and the activities of the Office of Conservation. This appendix contains a sampling of some of the more significant documents. These reports are not given a detailed critical review. Further, their citation here does not in any way suggest agreement or dissent from their findings. They represent a body of work relevant to the subject of this report and are cited for the convenience of readers who may wish to review related evaluations of energy conservation research.

Perspectives on progress in energy conservation, including analysis of how the U.S. market as responded to higher imported oil prices are provided by Trends in Industrial Use of Energy (Marylay, 1985, A Retrospective Analysis of Energy Use and Conservation Trends: 1972-1982 (Adams et al., 1985), and Energy Use Trends in the United States: 1972-1984 (Battelle Pacific Northwest Laboratory, 1985).

Battelle Pacific Northwest Laboratories (Hopp et al., 1981, 1982), under contract to the Office of Conservation's Energy Conversion and Utilization Technologies (ECUT) program, conducted a thorough study of research opportunities related to energy conservation. The study focused on "research opportunities that most likely will not be addressed by private industry." Identifying such research opportunities is an integral part of the planning process and these two reports remain an important reference.

There are a series of National Research Council (NRC) reports that examine the policies, performance, and portfolios within the Office of Conservation in various ways. Innovative Research and Development: Opportunities for Energy Efficiency (NRC, 1986a) focuses on the Energy Conversion and Utilization Technologies (ECUT) program. It finds that the office is not adequately equipped to develop many important energy conservation research opportunities. Issues in Electric Energy Systems (NRC, 1986b) examines the portfolio of research and development (R&D) work for the electric energy systems program. It finds the program to be underfunded and its portfolio not fully consistent with the needs of the industry.

Assessment of the Industrial Energy Conservation Program (NRC, 1985) reviews the industrial energy portfolio in detail, and in general, finds it to be well conceived and balanced. It identifies several additional opportunity areas for research and encourages a policy of cost sharing with the private sector as a means of effectuating technology transfer. It also encourages a continued focus on the longer-term, higher-risk R&D projects, which are less prone to attract corporate cost sharing.

Finally, three reports are cited to indicate that the NRC's input to the Department of Energy's Office of Conservation and other offices spans several years: (1) A Comparison of Alternative Energy Storage Systems for Automobiles (NRC 1982a); (2) Energy Conservation in Buildings and Community Systems (NRC, 1982b); and (3) Diesel Technology: Impacts of Diesel-Powered Light Duty Vehicles (NRC, 1982c).

The above-cited reports all represent indirect contributions to the multi-year planning process. While they are NRC publications, they are the individual products of independent study committees and their conclusions and recommendations do not necessarily represent the views of this committee.

The Department of Energy (DOE) maintains an in-house mechanism for the continuous review and evaluation of programs, the Energy Research Advisory Board (ERAB). ERAB has published several reports relevant to this study. One, The Department of Energy Multi-Program Laboratories (ERAB, 1982), recommends ways to strengthen the effectiveness of the national laboratories for advanced energy technology research. Those recommendations continue to merit consideration.

Energy Conservation and the Federal Government: Research, Development, and Management (ERAB, 1983a) assesses the need for the federal role in the context of industrial R&D programs and supports a portfolio of long-term, high-risk projects. The report expresses concern with DOE's management of energy conservation: "Personnel shifts and losses, low and shifting funding levels, and lack of planning have had a disastrous effect on the Department of Energy's ability to conduct an effective energy conservation R&D program." The report also concludes: "The federal government should undertake R&D directed at reducing its own energy consumption. The federal government has a poor record of energy management for its own use."

The Federal Role in Energy Research and Development (ERAB, 1983b) looks at the conservation program and makes specific portfolio recommendations for DOE support including research to support energy conservation by federal facilities and installations.

More recently, ERAB published its Guidelines for DOE Long Term Civilian Research and Development (ERAB, 1985 a,b,c,d,e,f). Among other recommendations applicable to the Office of Conservation, the report recommends actions to "dramatically upgrade DOE's R&D management capabilities." Actions recommended include "reorganize, stabilize, and implement strategic planning, intensify meaningful industry interactions, upgrade staff quality, terminate weak programs, and improve the management procedures for the national laboratories."

The above ERAB report deals with many of the same issues dealt with in this report. In particular, ERAB (1985b) strongly encourages strategic planning and concludes that "multi-year R&D funding requires strengthened planning. It is not sufficient to plan funding levels for different technologies independent of the reality of limited budgets." ERAB cites the Office of Conservation's MYP as an exception to the general lack of long-range energy planning within DOE. ERAB encourages the effort, noting that "these were not intended to be meaningful strategic plans and have not been used for establishing long-term R&D priorities, setting goals, or allocating resources, nor are they used for R&D program balance and control". Finally, ERAB (1985e) focuses specifically on the Office of Conservation, detailing its recommendations for the federal role in buildings, transportation, industry, cogeneration, demand-side management, and agriculture.

The ERAB report was not published until December 1985 and not obtained by this committee until February 1986, after the first draft of this report had been completed. This is noted to emphasize that the the committee performed its study independent of the work of the ERAB panel and there was no coordination between the two studies. This being the case, it is noteworthy that this report confirms and reinforces several of ERAB's key findings, focusing on the Office of Conservation as a case study of DOE's civilian R&D. While the ERAB work was of much larger scope, this report goes further in the area of long-range multi-year planning, as the major issue dealt with herein. ERAB provided valuable data and insight through its reports and through the participation of its members at the committee's roundtable (Appendix A).

In addition to the ERAB evaluations, the Office of Conservation benefits from ongoing reviews of many aspects of its planning and portfolio operations. An example is a report prepared to assist the process of project evaluation in the industrial energy area (Energetics, 1985). This report suggests introducing a quantitative evaluation methodology into portfolio selection.

A recent report by a former DOE assistant secretary for conservation and solar energy (Collins, 1985) reviews the programs based on his personal experience. Among his comments are [as paraphrased]:

- Varying degrees of congressional interest have led to an often-times crazy quilt of research emphasis. . . . Government interest since the early 1970s has lacked a pattern.
- The research that may be most important has not been done.
- Congress, the administration, and others are interested in measurable results.
- The lack of consistent professional survey research is a particularly acute problem in the conservation and energy efficiency field.

The committee shares concerns for the issues raised, as reflected herein, but does not necessarily agree with the wide-ranging views of the Collins report.

While the DOE literature generally emphasizes management and program improvements, the Congressional Research Service has evaluated many aspects of the Office of Conservation's operations from the point of view of policy formulation (Crane and Hack, 1984; Marcus, 1985; Schacht, 1985a,b; and Sissine, 1985a,b). These studies have helped the committee understand the larger policymaking context within which the Office of Conservation must do its long-range planning.

There is also a significant amount of literature on energy conservation research generated without government support. For example, several public interest lobby groups advocate a larger federal commitment to energy conservation research. Some publish independent analyses of the benefits from such research (American Council for an Energy Efficient Economy, Energy Conservation Coalition, 1986).

In evaluating planning efforts for energy conservation research, the committee looked at similar programs in several other countries. The International Energy Agency (IEA) published a review of the energy policies and programs of its 21 member countries (IEA, 1985). The Office of Conservation stays informed of developments in foreign countries, as shown by a recent consultant report that reviews industrial energy conservation programs in West Germany, France, Sweden, and England (Hagler, Bailly and Company, 1985). DOE has also contracted with Battelle for a study of developments related to energy conservation research in Japan (Hane et al., 1984).

Finally, it is important to note two documents that reflect detailed multi-year planning processes. The Electric Power Research Institute (EPRI) plans to spend $1.8 billion over a five-year period (1985-1989), mostly on (R&D) (EPRI, 1985). Similarly, the Gas Research Institute (GRI) plans to spend almost $1 billion in the same period (GRI, 1985). The plans show what two major, private research institutions think their respective industries need or want in the way of R&D. Their plans are also relevant because of the planning methodologies used and the method of displaying the results of the planning process.

APPENDIX C

FRAMEWORK OF PLANNING GUIDANCE FOR MYP 1987

TABLE C-1 Hierarchy of Planning Guidance as Contained in the Multi-Year Plan MYP FY 1987

Level Of Guidance	Page Number MYP FY 1987	Table
(1) Federal Science and Technology Policy		
o Science policy	32	C2
o Technology policy	33	"
o R&D policy	33	"
(2) Department of Energy Policy		
o Goal	30	C3
o Objectives	32	"
o Strategies	32	"
(3) Office of Conservation Primary Planning Guidance		
o Mission statement	3	C4
o Objectives	3	"
o Strategy for planning	5	"
o Criteria for prioritization and evaluation	36-37	C8
(3a) Office of Conservation Supplemental Planning Guidance		
o Strategic objectives	19	C5
o Specific objectives	28-29	C6
o Conservation mission objectives	30	C7
o Mission-related objectives	30	C7
(4) Specific Program Office Guidance: Goals, Objectives, Strategies		
o Buildings and community systems	39-40	C9-10
o Transportation	95-96	" "
o Industry	125	" "
o Systems: - Energy conversion	169-170	" "
- Electrical energy	201	" "
- Storage	231-32	" "

Table C-2 Guidance Based on Federal Science and Technology Policy

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Science Policy

- Enhance the contribution of science to the two most pressing long-term needs of the United States: national defense and the international competitiveness of U.S. industry.
- Maximize the return on national R&D investments.
- Ensure the long-term vitality of the U.S. science and technology base.

Technology Policy

- Ensure that U.S. scientific leadership results in economic and defense leadership.

Research and Development Policy

- Federally sponsored R&D must be responsive to society's needs rather than be performed simply to satisfy intellectual curiosity.
- R&D strategy must focus on technologies that will provide the basis for industries of the future.
- The federal government supports R&D activities to meet selected national needs, where the government shares responsibility with the private sector.
- The government will support research activities that result in new knowledge from which commercial technology may ultimately be derived.

SOURCE: DOE, 1985, pp. 32-33.

TABLE C-3 Department of Energy Policy: Goal, Objectives, and Strategies

---

Goal

- The goal of the national energy policy is to foster an adequate supply of energy at reasonable costs.

- To achieve this goal, DOE pursues "three more specifically focused objectives:"

  (1) Energy stability
  (2) Energy security
  (3) Energy strength

Strategies

- The strategies for pursuing the above goals are given as:

  (1) Minimize federal control and involvement in energy markets while maintaining public health and safety and environmental quality.
  (2) Promote a balanced and mixed energy resource system.

SOURCE: DOE, 1985, p. 30.

TABLE C-4 Office of Conservation: Primary Planning Guidance--Mission, Objectives, Strategies

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MISSION STATEMENT (p. 3)

The Mission of the Office of Conservation is to encourage the development of energy conservation's potential.

OBJECTIVES (p. 3)

Primary

(1) Improve the efficient use of energy resources.
(2) Increase flexibility and diversity of end-use technologies.
(3) Ensure resiliency and reliability of end-use systems.
(4) Understand health and safety implications.

Subsidiary

(5) Strengthen U.S. technological leadership.
(6) Improve U.S. competition in international trade.
(7) Mitigate environmental impacts.
(8) Reduce consumer energy costs.

STRATEGIES (p. 5)

- Pursue the highest potential return on investment (in terms of the goals and objectives of the office);
- Conform to guidelines for appropriateness of federal involvement; and
- Provide balance and diversity in the composition of the collective portfolio.

SOURCE: DOE, 1985, Chapter 1.

TABLE C-5 Supplemental Framework: Strategic Objectives

Emphasize strong market-oriented energy policies with three strategic objectives:

(1) U.S. and global energy security.
(2) Efficient use of resources.
(3) Sustained long-term economic growth.

SOURCE: DOE, 1985, p. 19.

TABLE C-6 Supplemental Framework: Specific Objectives for Conservation Programs and R&D Portfolio Planning

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(1) Improved efficiency across all sectors of the economy and the full realization of this potential remains at the forefront of DOE's conservation objectives
(2) . . . increasing fuel use flexibility and diversity of technical options
(3) . . . improved energy systems reliability, resiliency and efficiency
(4) . . . reliable and comparative information be available to consumers
(5) . . . development of advanced, high efficiency technologies in the industrial sector
(6) . . . technology leadership...particularly . . . in international trade
(7) . . . environmental impacts, health, and safety . . . need to be research, understood, and accommodated.

SOURCE: DOE, 1985, p. 28.

TABLE C-7 Supplemental Framework: Conservation Mission Objectives and Mission Related Objectives

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Conservation Mission Objectives:

- Increase energy end-use efficiency.
- Increase fuel use flexibility.
- Diversify energy end-use technologies and availability of options.
- Assure energy end-use systems reliability.
- Encourage efficient and fully competitive end-use markets.
- Understand health effects of conservation-related technologies.

Mission-Related Objectives:

- Maintain and strengthen U.S. technological leadership.
- Improve competitiveness of U.S. industries in international trade.
- Mitigate (through more efficient use) environmental impacts of:

  - energy combustion,
  - energy mining and production, and
  - energy byproducts and waste disposal.

SOURCE: DOE, 1985, p. 30.

TABLE C-8 Criteria for Ranking and Evaluation of Projects

- The relative importance of a given project to the achievement of a broader technical goal;
- Certain nonenergy benefits (e.g., technical leadership, industrial competitiveness, emergency preparedness, and reliability);
- Federal costs and the degree of private sector cost sharing;
- The degree of risk associated with the costs of project failure, compared with the net present value of anticipated benefits; and, importantly,
- The appropriateness of federal involvement.

SOURCE: DOE, 1985, p. 36-37.

TABLE C-9 Comparison of Elements in Program Office Goals and Objectives

	Buildings and Community Systems	Transportation	Industrial	Energy Conversion & Utilization Technologies
Goals				
1. Increase efficiency of energy use	●	●	●	
2. Enhance fuel use flexibility		●	●	
3. Expand knowledge base of energy technologies				●
Objectives				
1. Advance scientific understanding of energy use and/or related scientific phenomena	●	●		●
2. Accelerate introduction of new energy efficient equipment	●	●		
3. Support development of voluntary standards	●			
4. Maintain and update scientific test procedures	●			

TABLE C-9 continued

	Buildings and Community Systems	Transportation	Industrial	Energy Conversion & Utilization Technologies
Objectives (continued)				
5. Encourage availability of consumer information	●			
6. Transfer R&D results to the private sector	●	●	●	●
7. Carry out mandated programs	●		●	
8. Select high-risk technologies on a cost-shared basis			●	
9. Select R&D which will not be done by the private sector			●	
10. Develop improved techniques processes and materials				●
11. Explore novel, innovative and revolutionary concepts				●

SOURCE: DOE, 1985, pp. 39, 95, 125, 169.

TABLE C-10 Comparison of Elements in Program Office Strategies

Strategies	Buildings and Community Systems	Transportation	Industrial	Energy Conversion & Utilization Technologies
Understand state-of-the-art	●			
Identify problems and opportunities	●	●		
Identify decision factors on R&D	●			
Select R&D which will not be done by private sector but meet objectives	●	●		●
Facilitate availability of information to consumer and private sector	●	●		●
Implement regulatory programs	●			
Serve as consultant in area of expertise	●			

TABLE C-10 continued

	Buildings and Community Systems	Transportation	Industrial	Energy Conversion & Utilization Technologies
Strategies				
Identify use of energy by mode/fuel		●		
Estimate potential improvements		●		
Compare based on energy savings		●	●	
Consider risk, costs, and net economic benefits			●	
Accelerate implementation of technology			●	
Consider degree of benefits accrued to fragmented industries			●	
Focus on long-range emerging areas with limited private sector support				●

SOURCE: DOE, 1985, pp. 40, 96, 125, 170.

STATEMENT FOR THE RECORD OF
DAVID O. WEBB, SENIOR VICE PRESIDENT
POLICY AND REGULATORY AFFAIRS, GAS RESEARCH INSTITUTE
BEFORE THE SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
SENATE ENERGY AND NATURAL RESOURCES COMMITTEE
MARCH 26, 1987

I appreciate the opportunity to submit testimony which presents Gas Research Institute's (GRI) FY 1988 budget recommendations for gas-related research in the Department of Energy's (DOE) Conservation and Solar and Renewables R&D programs. The recommendations reflect the minimum funding required for a viable gas research program. In developing these recommendations, GRI considered the severe pressure on the federal budget and the need to reduce expenditures. In this vein, GRI and the gas industry have agreed on a recommendation of $48 million in the above-mentioned programs. Of this recommendation, $27 million is for conservation R&D, which is the same level of funding Congress appropriated for conservation R&D for FY 1987. Central to these recommendations is that GRI is planning to commit $72.3 million to near-term research in these same program areas in 1988.

GRI is an independent, not-for-profit scientific research organization that plans, manages, and finances a cooperative R&D program for the benefit of its 252 members and their customers. The R&D program is implemented through contracts with research organizations, engineering firms, universities, energy companies, and manufacturers. National energy R&D policy is a major factor influencing the GRI R&D program since GRI cofunds and coordinates many of its research projects with DOE. Therefore, congressional action on the proposed FY 1988 DOE budget has a direct impact on the gas industry's R&D program.

DOE ENERGY POLICY

The DOE FY 1988 budget request accelerates the shift started three years ago to increase funding for defense-related activities while significantly reducing spending for nonnuclear energy R&D. In fact, energy-related R&D in the DOE budget is now only approximately one-third of the total request, and funding for solar and conservation R&D is 45 percent less than Congress's appropriation for FY 1987. The most recent Congressional Budget Office report on the Administration's FY 1988 budget request clearly illustrates the drastic reduction in all nonnuclear R&D since 1981. (See Exhibit 1.) Funding for these programs has decreased by an average of 85 percent since 1981 compared with the FY 1988 request.

EXHIBIT 1
MAJOR CHANGES IN DOE NONNUCLEAR ENERGY PROGRAMS[1]
($ Millions of Budget Authority)[2]

DOE Program	Actual FY 1981	Actual FY 1983	Current FY 1987	President's Request FY 1988	% Change 1988/81
Solar Energy R&D	$549	$202	$124	$ 71	-87%
Energy Conservation R&D	292	134	162	80	-73%
Fossil Energy R&D	997	330	302	169	-83%
Geothermal Energy R&D	156	58	21	16	-90%
Electric Storage/Systems R&D	112	43	28	14	-88%

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[1] The percentage reductions do not reflect the effect of inflation on the real program level. Nineteen eighty-eight dollars are estimated to be worth only 77 percent of their 1981 value, so real reductions are even greater than displayed above.

[2] Source: Congressional Budget Office

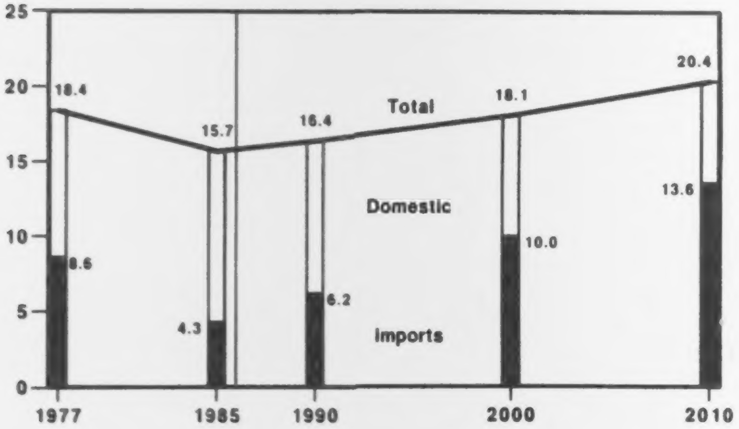
To further dramatize this shift in priorities, the Administration has requested $596 million for the Strategic Defense Initiative (SDI) program in the DOE budget. This is more than three times the total new budget authority requested for all solar and conservation research programs. This year during budget hearings DOE Secretary Herrington testified that DOE's $815 million budget request for the General Sciences Program is a 13 percent increase over the FY 1987 funding level. At the same time, he testified that the budget request for fossil, conservation, and solar and other renewables is $343 million--well below last year's appropriated levels. This budget does not acknowledge the critical role nonnuclear fuels and conservation will play in the U.S. energy future for the next 25 years. The policy of drastically curtailing essential, ongoing nonnuclear energy research while continuing to shift funding to weapons-related research invites severe problems in meeting the nation's future energy demands.

LIQUID FUELS OUTLOOK

A rapid increase in oil imports will result from an unbalanced energy research policy that concentrates nearly all R&D funds on nuclear energy, high-energy physics, and basic energy sciences while essentially ignoring fossil fuels and conservation R&D. U.S. consumption of oil is projected to increase, rising from 15.7 million barrels per day in 1985 to 18.1 million barrels per day in 2000. In the mid-1990s, imports will exceed the 1977 historic peak of 8.6 million barrels per day and are projected to reach 10 million barrels per day by 2000. (See Exhibit 2.)

EXHIBIT 2

U.S. OIL SUPPLY
(Millions of Barrels per Day)



1986 GRI Baseline Projection

Based on EIA's latest data, the nation's gross oil imports during 1986 exceeded 6 million barrels per day--an increase of 1 million barrels per day over the 1985 rate. Total U.S. demand reached 16.1 million barrels per day--the highest consumption level since 1980. Thus, if this trend continues, more than half of the U.S. requirements for petroleum will be imported well before 2000.

For DOE to propose to reduce research funding for the more efficient use of U.S. fossil fuels by 45 percent is not sound policy. The DOE budget, if enacted as proposed, will hasten the day when oil imports will rise to greater than 50 percent of total U.S. demand.

Over the past several years, Congress has stressed and has appropriated funds for development of domestic nonnuclear energy resources and the more efficient use of energy to reduce dependence on oil imports. Unfortunately, if the U.S. is to have a balanced energy program, Congress must once again restore funding to continue critical programs in DOE's conservation and solar R&D programs. The national energy policy should be based on a reasonable balance between energy use and energy R&D funding. The Administration's proposed budget does not strike such a balance.

GAS RESEARCH INSTITUTE'S 1988 BUDGET

In contrast to the DOE proposal to drastically reduce funding for long-term gas-related research, the gas industry's response to federal R&D policy directing industry to fund more of its own near-term R&D has been very impressive. While DOE has proposed only about $24 million for FY 1988 gas-related research in conservation and solar R&D programs--approximately one-half the level of FY 1987 appropriated funds--GRI will fund approximately $72.3 million of near-term activities in these research areas--a 25 percent increase over 1986. (See Exhibit 3.)

EXHIBIT 3
GRI FUNDING FOR SOLAR AND CONSERVATION RESEARCH
($ Millions)

	GRI 1986 Approved Funding	GRI 1988 Planned Funding
R/C Heating and Cooling	$ 7.0	$13.2
R/C Heat Pumps	13.1	17.2
R/C Gas Appliances	3.9	5.3
CNG Applications	1.6	1.7
Energy Cogeneration Systems	7.3	7.4
Industrial Utilization	19.3	21.3
Indoor Air Quality	2.1	2.0
Basic Research on Biofuels	4.1	4.2
TOTAL	$58.4	$72.3

An effective joint research effort by the government and industry requires DOE to do its part and fund a viable long-term gas research program. This is best illustrated by a General Accounting Office report dated February 11, 1987. It concludes that "private industry has not picked up much of the energy R&D curtailed by DOE." This lack of a viable DOE research effort has significantly delayed U.S. technology development.

To establish this joint effort, GRI is recommending $48 million in DOE's Conservation and Solar and Renewables R&D programs to fund the long-term technology base. (See Exhibit 4.) In the past four years, Congress has recognized the need for a long-term DOE gas-related program to supplement the near-term GRI program and has appropriated approximately $45 million each year for these DOE programs. The gas industry is seeking a continuation of this trend in FY 1988. Maintaining funding for ongoing DOE programs is critical if the U.S. is to develop the technology required to efficiently use its resources and reduce the dependence on imported oil.

EXHIBIT 4
RECOMMENDED DOE GAS-RELATED BUDGET FOR FY 1988
FOR CONSERVATION AND SOLAR R&D
($ MILLIONS)

	FY 1987 Congressional Appropriation	Gas Industry FY 1988 Recommendation
CONSERVATION		
Heat Pumps	$ 5.0	$ 8.0
Energy Conversion and Utilization Technology (ECUT)--Ceramics and Lubricants	6.0	4.0
Industrial Cogeneration and Waste Energy Reduction	10.0	5.0
Indoor Air and Building Systems	6.0	3.0
Desiccant Systems	0.0	2.0
Natural Gas/Diesel Vehicles	0.2	5.0
Subtotal	$27.2	$27.0
SOLAR AND RENEWABLES		
Biofuels	$12.1	10.0
Geopressured Resources	4.0	9.0
Liquid Spill Test Facility	2.0	2.0
Subtotal	$18.1	$21.0
TOTAL	$45.3	$48.0

RECOMMENDED DOE FY 1987 GAS-RELATED RESEARCH

With the gas industry's rapidly increasing its near-term research activities, it is critical for DOE to continue ongoing long-term gas research to have a viable national program. I will discuss important long-term programs in gas research that this Subcommittee previously supported that require continued federal funding.

CONSERVATION

Discussed below are several important long-term programs in efficient utilization gas research that are consistent with a balanced energy policy, have been supported previously by this Committee, and require continued federal funding.

	FY 1986 Appropriation	FY 1987 Appropriation	GRI FY 1988 Recommendation
Gas Heat Pumps	$ 4.2M	$ 5.0M	$8.0M

An Energy Research Advisory Board study reported "the manufacturing sector is so diverse that individual companies cannot capture the benefits of conservation R&D." Therefore, the federal research role becomes critical. Specific technology-based research is needed on advanced components, engines, and systems necessary to produce a competitive heat pump for residential and commercial markets by the early 1990s. Achieving this goal requires a joint DOE/gas industry program with funding of approximately $25 million per year.

The operating principle of heat pumps is the same as that of a common refrigerator, freezer, or air conditioner--they remove heat from some source and "pump" it to its destination. By extracting heat from the outside air and transferring it to the indoor space, heat pumps can actually supply more thermal energy than is contained in the fuel they use, even on cold days. The heat pump's cooling effect is accomplished by reversing this process. Currently, only mechanical heat pumps driven by electric motors are available for residential space conditioning.

The gas heat pump not only offers increased efficiency over existing gas-fired space conditioning equipment but also can provide heating and cooling in a single unit. Heat pumps can provide both heating and cooling in cold climates at a lower overall cost than would otherwise be possible. Commercial as well as residential heat pumps could also contribute to load leveling and reduction during peak demand for both natural gas and some electric utilities thereby reducing operating costs.

Gas currently provides winter heating comfort for more than 40 million families in the United States. In the approximately 4 million commercial buildings, over 55 percent have natural gas hookups, and 50 percent use gas for space heating. Therefore, developing a gas heat pump for the residential/commercial markets should be a top national energy priority. GRI has been working with DOE over the past five years to develop a cooperative research program. GRI is concentrating on the more near-term aspects of the research, and DOE is focusing on the longer-term advanced component and engine research necessary to develop a cost-competitive gas heat pump system.

The joint DOE/GRI program covers two broad categories of gas heat pump research: mechanical heat pumps and absorption heat pumps. Mechanical systems use gas engines instead of electric motors to drive a system in which a refrigerant vapor is alternately compressed and expanded in a continuous cycle. Absorption systems use the heat from gas combustion to sustain a fluid separation cycle employing evaporation and absorption.

Absorption heat pumps offer the potential advantages of higher reliability and lower maintenance costs than the mechanical systems since the absorption system uses relatively few moving parts. However, a mechanical system using an advanced gas engine has the potential to achieve a higher efficiency and thereby to increase overall cost competitiveness. Therefore, GRI has adopted a strategy that calls for development of a first-generation heat pump for market introduction by 1990 and an advanced heat pump using new engine technology for introduction in the mid-1990s. Internal-combustion engine technology and absorption technology are both being investigated for the early-entry heat pump. Stirling engine technology is GRI's primary approach to attaining its R&D goals for an advanced residential heat pump by the mid-1990s.

Reaching these goals will require a cooperative DOE/GRI research program. Although there are many difficult technical issues that must be addressed in each of these concepts, a common barrier is the first cost. The unit cost must provide a payback within at least five years, and the equipment must have a service life of approximately 40,000 hours. Therefore, to increase the likelihood that this kind of equipment will be available to U.S. homeowners and commercial building owners and operators in a timely manner, DOE and GRI have identified a national R&D program to advance this technology. The guiding principles are:

1. To pursue multiple parallel options.
2. To pursue near-term concepts with modest performance goals dictated by market considerations.
3. To develop advanced, long-term concepts with high-performance characteristics through research on components such as new engine concepts.
4. To transfer technology from near-term Japanese concepts to U.S. programs.
5. To focus technology transfer to industry on the GRI elements of the program.
6. To maintain a rigorous economic evaluation system throughout the program development period.

Most of the technologies being developed for eventual introduction into the market are major departures from current gas equipment. The current knowledge in the U.S. is very narrow; therefore, in addition to heat pump system development, a broad-based effort in advancing fundamental knowledge is needed. Some of this research conducted at leading universities should be generic and should focus on basic phenomena.

The four main elements of the joint DOE/GRI comprehensive gas heat pump program are:

1. System Development concentrating on R&D for an entire heat pump system or major component.
2. New Concepts Evaluation of promising technical approaches at a very early stage of development.
3. Supporting Research consisting of fundamental research in basic processes, phenomena, and materials; generic component development; and cross-cutting research on new analytical tools.
4. Systems Analysis focusing on studies to set generic R&D goals and to identify specific components and subsystems improvements.

These four program elements must be funded at a minimum level of effort or a critical mass if a fully competitive gas heat pump is to be available by the early 1990s.

The program structure and funding recommendations are similar to the Japanese development effort on small gas engine heat pumps. As of 1986, the Japanese government was sponsoring four heat pump systems under joint development with Japanese industry. These systems are undergoing preproduction and field test evaluation. Approximately 50 percent of the development funds are provided by the Japanese Ministry of International Trade and Industry (MITI), with the other 50 percent coming from the participating utilities and manufacturers. GRI is proposing a similar funding profile with DOE. DOE would provide $8 million in FY 1988, and GRI would provide $17.2 million.

The research funding should concentrate on two or three concepts for the commercial buildings market. Also, research should be conducted on adding domestic water heating to the commercial-size gas heat pump. Initial studies indicate the use of the engine reject heat to heat water provides a useful application during the summer months that could result in a 20 percent increase in overall system performance.

Multiple technological options are needed for the residential market to solve the critical problems of unattended performance, first cost, and reliability. The technology concepts being pursued include a dual-cycle absorption heat pump and heat pumps driven by reciprocating internal-combustion engines, rotary internal-combustion engines, and free-piston Stirling engines. The following table outlines the coefficient of performance (COP) targets for each of these concepts.

COP TARGETS OF GRI-SUPPORTED HEAT PUMP CONCEPTS

Residential	Heating	Cooling
Dual-Cycle Absorption	1.80	0.94
I.C. Engine (Reciprocating)	1.70	1.00
I.C. Engine (Rotary)	1.70	1.00
Free-Piston Stirling	1.80	1.10

Development of small internal-combustion engines for use in heat pumps would have many applications, primarily in cogeneration. Initial research has shown that the needed improvements in engine life, maintenance requirements, and controls are definitely achievable. Several attractive long-term technologies, specifically free-piston Stirling engines and free-piston internal-combustion engines, show potential. These are being developed as an element of the gas heat pump program and should be continued due to the early stage of development and high technical risk. Research needs to be conducted in the areas of dynamic component matching, improved high-temperature materials, ceramic development and application, seal technologies, heat exchangers, use of electronic engine controls, and high-temperature lubricants.

A viable gas heat pump and prime mover program requires a joint federal/gas industry effort with DOE funding $8 million in FY 1988.

	FY 1986 Appropriation	FY 1987 Appropriation	GRI FY 1988 Recommendation
Natural Gas/Diesel Vehicles	$ 0.0M	$ 0.0M	$ 5.0M

In the late 1970s, increased gasoline and diesel fuel prices and related concerns about gasoline rationing generated renewed worldwide interest in natural gas as an alternative to gasoline and diesel fuel in stationary and mobile engines. Continued concern over the reliability of imported petroleum supplies also prompted several domestic and foreign automobile manufacturers to evaluate a broad range of fuel alternatives including natural gas. While the competitiveness of natural gas vehicles (NGVs) is extremely sensitive to assumptions about capital costs, fuel costs, and resale value, the potential market for these vehicles is appreciable. Several analyses of both vehicle usage patterns and existing institutional barriers to increased utilization of natural gas fuel have helped identify certain fleet vehicles as the most promising near-term application for the large-scale penetration of NGVs.

Recent environmental concerns have been an issue as well. The Environmental Protection Agency recently issued new standards for vehicles that immediately affect heavy-duty diesel vehicle fleets. These standards are "technology forcing" regulations. Specifically, the 1991 limit for transit bus diesel particulate emissions is 0.1 G/BHP-HR (grams per brake horsepower-hour). This is beyond the state of the art for conventional diesel technology. A demonstration program would be beneficial to determine the contribution a natural gas vehicle or natural gas/diesel vehicle would make towards meeting EPA's regulations.

Environmental emissions from NGVs will depend on the degree to which engine calibration and hardware configurations are optimized to utilize natural gas. Currently, available exhaust emissions data are quite inconclusive with respect to the environmental benefits of natural gas as a vehicle fuel versus alternatives such as gasoline and methanol. This is particularly true of compression-ignition (diesel) engines converted to use natural gas and late-model spark-ignition vehicles using computer-controlled emission systems. There is a need for a comprehensive NGV emissions data base to help establish engine conversion kit research goals and to ensure that this technology remains an environmentally acceptable application of natural gas.

There is little data available today by which to determine the contribution natural gas/diesel engines might make in meeting current and future EPA standards. GRI is currently developing a retrofit kit and compiling some preliminary data to help determine the impact of natural gas use to meet these standards and to be used as a basis for demonstration of natural gas/diesel in two-stroke diesel engines which make up about 95 percent of the heavy-duty public transit vehicles. GRI and the gas industry urge DOE to join in a demonstration of heavy-duty diesel engines. It is recommended that DOE pick up the cost of the vehicle conversions and the compression stations. Testing should be done in both northern and southern climates with six to ten heavy-duty vehicles in each station. A mixture of urban expressway and intracity busses is required with a minimum operation of 12 to 18 months.

GRI's 1987 budget for natural gas application in transportation totals $1.725 million. The federal requirement for a technology base program in FY 1988 is $5 million.

Energy Conversion & Utilization Technology (ECUT)-- Ceramics	FY 1986 Appropriation	FY 1987 Appropriation	GRI FY 1988 Recommendation
	$2.0M	$2.7M	$4.0M

The advantages of structural ceramic materials versus metal alloys are well documented. Because ceramics are lightweight, retain their strength at high temperatures, and have high corrosion and wear resistance, they can increase process efficiency through higher-temperature operation, reduce equipment complexity and maintenance through the use of noncooled components, and increase equipment life due to improved corrosion and wear resistance. To help ensure that these potential benefits of ceramic materials are fully realized, however, R&D is needed to address several technical issues that have impeded wide market penetration.

The key elements used in ceramics manufacture--aluminum, silicon, zirconium, titanium, carbon, nitrogen, and oxygen--are relatively abundant and inexpensive. This is in marked contrast to the uncertain supply and cost outlook for some strategic metals common in the manufacture of high-temperature metallic components. However, labor-intensive fabrication techniques geared toward limited-volume production of ceramics have resulted in high component and system costs. Reliability and cost are particularly important issues in the production of large components with variable geometries. Research is needed to develop more systematic fabrication techniques for the forming and sintering of more reliable ceramic parts and reproducible and cost-effective manufacturing and quality control techniques for the large-scale production of reliable ceramic materials and components.

GRI recently signed a five-year agreement with Pennsylvania State University for $10 million for research in the engineering use of ceramics. The funding will be used to set up the Center for Advanced Materials to provide a focal point for research and to bridge the gap between the advanced materials suppliers and the equipment manufacturers and users.

In addition, GRI's 1988 budget for industrial and high-temperature ceramics and components is $4 million. The recommended program for DOE is $4 million to be funded as part of the Energy Conversion and Utilization Technology (ECUT) program.

Building Envelope Systems	FY 1986 Appropriation	FY 1987 Appropriation	GRI FY 1988 Recommendation
	$4.0M	$6.0M	$ 3.0M

GRI's objective in the building envelope systems area is concentrated on ensuring that there is a proper integration of the variety of high-efficiency gas space-conditioning and appliance concepts into a building space-conditioning system. In an actual structure, many factors can interact to degrade the performance of energy-using equipment. Specifically, research is needed to provide improved understanding of parameters such as heating and cooling system efficiency, air infiltration, room-to-room heat transfer, interactions between equipment, control-system design, and energy distribution systems. This knowledge can lead to the development of more accurate techniques for modeling and analysis and, consequently, to improvements in both existing and new structures and in gas space-conditioning equipment and appliances. This research is also needed to help provide data on the application of conservation techniques to many households served by gas utilities. This is particularly important in low-income apartment buildings where lack of capital and limited information constrain the application of energy conservation measures.

One way in which GRI is accomplishing these objectives is through participation with the National Association of Home Builders/Research Foundation in the "SMART HOUSE" project located in Gaithersburg, Maryland. That project is an ongoing effort by home builders and more than 30 U.S. manufacturers to develop advanced technologies for the home of the future that will combine the efficient use of energy with the convenience of advanced communication and control systems.

GRI's budget for building systems research in 1988 is $2.5 million. The gas industry recommends $3 million for the federal effort for continued research in indoor air quality research and building envelope systems.

	FY 1986 Appropriation	FY 1987 Appropriation	GRI FY 1988 Recommendation
Desiccant Systems	$ 0.0M	$ 0.0M	$ 2.0M

Today, the cooling needs of most small commercial buildings are being met with electric vapor compression air conditioners and heat pumps. However, in areas of the country that experience high humidity and in commercial buildings that have high internal humidity loads, the use of these systems to handle both the moisture (latent) and cooling (sensible) loads is often inefficient in terms of energy and equipment utilization. An alternate and more efficient approach is the use of an integrated gas-regenerated desiccant dehumidifier in conjunction with a smaller-capacity electric vapor compression air conditioner. Warm air from a gas burner is used to dry or regenerate the desiccant material which absorbs or removes moisture and thereby handles the latent cooling load. An electric air conditioner meets the sensible load.

Desiccant cooling can be separated into a straightforward direct or indirect evaporative cooling combined with dehumidification. Moisture control in buildings has been a significant problem in the past, and recently air quality has gained attention. Desiccant cooling cycles offer a unique opportunity to attack moisture problems as well as air cleanliness.

GRI is field testing the concept of an integrated gas desiccant/electric air conditioner in several supermarkets. A supermarket is a good application for such a system since the operation of freezer and cooler cases reduces the sensible load and leaves approximately one-half of the air conditioning load to provide dehumidification. Current systems result in oversized air conditioners which are operated at high load factors and low evaporative coil temperatures. The result is poor efficiency and high operating costs.

While GRI concentrates on these near-term integrated gas/electric systems, DOE should initiate research on more advanced gas desiccant systems. The research should have as its goal a total desiccant cooling system (no electric cooling components) in sizes from 10 to 20 tons.

Key technology improvements are needed in reducing the size and cost of the systems and to develop systems which are compatible with many applications. A cooperative DOE/GRI program is recommended in the components area to start development of advanced dehumidifiers, heat exchangers, and evaporative coolers; to assess the air quality resulting from possible contaminants in desiccants; and to test polymers and develop a data base of desiccant polymers. In addition, DOE should expand its current program to further develop open cycle desiccants and building dehumidification and to further develop new concepts including high-performing cost-effective geometry/material combinations which must be supported by model validation and verification testing of prototype concepts.

GRI's 1988 budget for desiccant systems is approximately $2.8 million. The FY 1988 federal contribution needed for this long-term effort is $2 million.

	FY 1986 Appropriation	FY 1987 Appropriation	GRI FY 1988 Recommendation
Industrial Cogeneration	$4.7M	$5.0M	$5.0M

Cogeneration is a process in which useful thermal energy and electricity are produced simultaneously from a single fuel source. Although the concept of cogeneration is well known, it is not used extensively, and the technology is by no means mature. As more efficient, cost-effective systems are developed, cogeneration may emerge as one of the nation's important energy-saving technologies and as an important new market for the U.S. gas industry.

Gas-fired cogeneration can supply both electrical and thermal energy service in a highly efficient manner. The environmental and strategic benefits of gas-fired cogeneration are also significant, since efficient use of clean-burning gas from domestic sources decreases total emissions and helps reduce dependencies on imported petroleum fuel supplies.

Energy conversion efficiencies in the 30 percent range, typical of equipment currently dominant in industrial and electric power-producing installations, are no longer economically competitive. Cogeneration of electricity or shaft horsepower and useful heat at overall efficiencies of 70 to 80 percent are possible through a coordinated federal/industry research program. New approaches that meet the combined thermal, shaft horsepower, and electrical requirements of an industrial facility are needed.

The GRI effort is focused on near-term problems of demonstrating cost-effective packaged cogeneration systems for the commercial and light industrial markets. GRI's industrial sector R&D program, with substantial technical and financial support from industrial equipment manufacturers and end users, is structured to overcome the present constraints facing the industrial gas consumer. GRI is currently developing packaged cogeneration systems in sizes ranging from 50 to 1000 kilowatts of electrical output. These units will have greater than 75 percent overall efficiencies at installed costs of less than $1000 per kilowatt for application in commercial buildings and multifamily dwellings.

DOE needs to take a role in the longer-term research needs to establish and conduct a program to develop advanced materials and advanced heat transfer and thermodynamic and microprocessor concepts. These components and concepts must then be integrated into prototype units to allow industry to evaluate the effectiveness of the systems. This R&D will improve the cost-effectiveness, efficiency, reliability, and flexibility of cogeneration systems. The result is increased cost savings and expanded potential applications for gas-fired cogeneration systems. Improved components from this DOE-sponsored research can be integrated into both first- and second-generation packaged systems.

GRI's cogeneration budget for 1988 is approximately $8.85 million. The recommendation for the federal effort is $5 million.

SOLAR AND RENEWABLES

	FY 1986 Appropriation	FY 1987 Appropriation	GRI FY 1988 Recommendation
Biofuels	$19.0M	$12.1M	$10.0M

RefCoM (refuse converted to methane) is a project originally supported by DOE/ERDA. Initially, it demonstrated the biological gasification of municipal solid waste and sewage sludge to produce a methane-rich gas. The program progressed through 1982 when it was discontinued. The program was again funded in 1984 by DOE, GRI, and Waste Management, Inc., to study methane yield, solids reduction and ultimate disposal, mixing characteristics, effluent dewatering, process stability, and energy and chemical requirements.

Based upon results to date, a validation of the RefCoM process in a large-scale field experiment is an appropriate next step. While the technology could have gas industry implications in many situations, there is a broader base of application of the technology where the product gas could be sold "over the fence" as 500 Btu/standard cubic foot of gas or used internally to satisfy both a waste disposal problem or a portion of a larger energy requirement. Therefore, it is appropriate that DOE continue to support the development of this technology. Funding of the RefCoM project at DOE is recommended at $2 million.

The Walt Disney World project was originally known as the Water Hyacinth Project. It began in 1978 with support first from NASA, EPA and WED Enterprises followed by funding by United Gas Pipe Line Co. and DOE. Its sole objective was nonenergy-intensive wastewater treatment. The successful completion of the wastewater treatment studies led to new areas of research. Under the current sponsor, GRI, the project is evaluating the utilization of a spectrum of community wastes to methane. The overall objective is to develop a multipurpose anaerobic digestion system capable of converting blends of community wastes including sewage grown biomass, sewage sludge, municipal solid waste, industrial wastes, and biomass to cost competitive, pipeline quality methane.

Additional support for the program at Walt Disney World and the associated technology development efforts is required. The reactor at WDW is an advanced reactor that is demonstrating superior performance over available state of the art. Further characterization, optimization, and evaluation of the concept is required, and studies need to be carried out to assess the system and economic implication of this technology for the gas industry and municipalities. It offers an alternative to the mass burning technology that may have both environmental and economic advantages.

A DOE contribution of $2 million is required for the Walt Disney World project. GRI's budget in biomass programs in 1988 totals $4.2 million.

SUMMARY

GRI recommends DOE fund a viable, consistent gas-related budget in DOE's Conservation and Solar and Renewables programs which adequately addresses the long-term needs of this nation's energy supply. A total of $48 million in FY 1988 would continue programs Congress has already approved. We believe this budget recommendation is consistent with the realities resulting from a large federal deficit since it is essentially the same as last year's appropriations for these same programs. It should be noted that the gas industry is funding near-term research in these program areas with a GRI R&D budget of $72.3 million. These central themes of funding adequate long-term gas research in DOE while GRI funds near-term research are sound national energy policy.

GAS INDUSTRY RECOMMENDATION
FY 1988 GAS-RELATED DOE CONSERVATION
AND SOLAR BUDGET
($ Millions)

CONSERVATION R&D	
Heat Pumps	$ 8.0
Energy Conversion & Utilization Technology (ECUT)--Ceramics and Lubricants	4.0
Industrial Cogeneration	5.0
Indoor Air & Building Sytems Research	3.0
Desiccant Systems	2.0
Natural Gas/Diesel Vehicles	5.0
Subtotal	$27.0
SOLAR AND RENEWABLES R&D	
Biofuels	$10.0
Geopressured Resources	9.0
Liquid Spill Test Facility	2.0
Subtotal	$21.0
TOTAL	$48.0

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State University System of Florida

March 13, 1987

The Honorable Wendell H. Ford
Chairman, Energy Research and Development Subcommittee
Energy and Natural Resources Committee
Dirksen Building
Washington, DC 20510

Dear Chairman Ford:

I want to thank you and the Energy Research and Development Subcommittee for the opportunity to provide these remarks for the record on DOE's renewable energy program. As you are aware, the Senate has provided funding during the past several years for research topics of interest to the State of Florida. These topics include buildings, hydrogen and photovoltaics. The Florida Solar Energy Center has conducted extensive research on these topics in cooperation with federal agencies and with private companies. Through my experience as an active participant in each of these programs, I submit the following observations and recommendations:

1. Solar Buildings Research Program - A major part of the federal solar buildings program is a Congressionally initiated long-term effort into a new area of buildings research, which is aimed at solution of the cooling and dehumidification problems encountered in new residential and commercial buildings. The goal of this five-year cooling and dehumidification project is to save 50 to 75 percent of the energy needed to cool buildings.

   This buildings research program has already provided new information that is of value in excess of the research costs. For example, recent Congressional testimony before the House Science, Space and Technology Committee by Oak Ridge National Laboratory cited radiant barrier technology as being capable of saving 0.17 quads of energy in the South alone. The Florida Solar Energy Center has conducted pioneering research in this emerging building technology over the past five years, supported primarily by State funds.

   The present project conducted by Florida Solar Energy Center has a strong base of private industry support; nearly 50 percent of its 1987 funds has been provided by industry. To maintain this industrial support, DOE support must continue. Thus, we strongly recommend that Congress continue funding of this research project by

AN EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER

providing $1.5 million in the FY 1988 budget and to earmark these monies for this vital new government-industry partnership. We further recommend that Congress increase the overall DOE solar buildings program budget for FY 1988 to a level approaching that of FY 1986 in order that component solar building research can continue in a supportive and coordinated manner.

2. Hydrogen Production and Utilization Research Program - Hydrogen may well be the best energy option for sustaining and supporting human society. Currently, our major use of hydrogen as a fuel is for the Space Shuttle. Very soon it will be needed for stationary applications on board the Space Station. Development of transatmospheric vehicles could easily double or triple its demand. DOD and NASA plan to spend $3 billion over the next seven years to design and construct such vehicles, and their program managers are counting on the Department of Energy to develop cost-effective hydrogen fuels.

   There are additional reasons for supporting hydrogen research now--the greenhouse effect, acid rain, the need for alternatives to gasoline and jet fuel and our national security to name just a few. Development of renewable or solar-produced hydrogen fuel appears today to be our best long-term option. At this juncture, we need to determine the best hydrogen production technology and the time frame for its implementation.

   To this end, Congress recognized the need for the hydrogen from renewable energy program when it provided initial funding in FY 1985. With those funds, DOE directed Florida and Hawaii to assess the status of hydrogen technology and to determine priority research areas.

   In 1986, Congress again recognized the need and urgency for upgrading the national hydrogen program when it introduced bills on the topic in both houses (S. 1685 and H.R. 3899), and provided further funding in FY 1987 of $1.2 million to continue research on hydrogen from renewable resources.

   It is imperative that the work on the prioritized research issues be continued; thus, we recommend that Congress continue, at level funding, the hydrogen from renewables program for FY 1988 at $1.2 million. These funds should be specifically designated within the DOE renewable energy budget.

3. Photovoltaics Research Program - Photovoltaics is the most promising of the solar technologies. Every individual familiar with the technology predicts enormous future success for its use. Our involvement in photovoltaics technology has grown through five years of operating the photovoltaic Southeast Regional Experiment Station (SE RES).

   This $6 million research program has resulted in solution of many of the utility interface problems and in the increased application of photovoltaics. There is a continued need for the SE RES and its work with Sandia National Laboratories in a variety of important areas. One of the major areas needing attention in FY 1988 is the testing and evaluation of new single-junction and tandem thin-film modules to determine their reliability, stability and power production in system operation. This national program is a resource that must be continued. As such, it is requested that $600,000 ($300,000 each) be provided to operate the Southeast and Southwest RESs.

Japan, Germany and Italy now have larger government-funded photovoltaics R&D programs than the U.S. Photovoltaics is a technology that must not -- as many have -- be abandoned to foreign competition. Therefore, we also recommend that at least level funding be continued for the entire photovoltaics program.

Your consideration of these valuable solar programs in the Senate authorization is recommended and will be appreciated.

Sincerely yours,

David L. Block, Ph.D., P.E.
Director

DLB:cjb/sc

AN ADVANCED NEAR-TERM BATTERY FOR LARGE-SCALE STORAGE

The Nation's industrial and residential energy needs are being met increasingly with electricity. The electric utilities, however, are in a state of flux. Significant changes in their ability to respond to the need for more, and more reliable, electric power are expected. These will come about, many believe, because of the effects of rising interest rates, the influence of PURPA, the advent of wheeling, the phase down of our nuclear generating capacity, an aging non-nuclear generating system, increasing fuel costs, and acid-rain legislation. The effect of each of these is to reduce the near-term availability and reliability of an energy system most citizens have long taken for granted.

Large rechargeable batteries could provide an important increment in the reliability of that threatened system.

Batteries could provide storage near the generating sites allowing the utilities to optimize the operation of their base-load plants. Storage could be on the customer-side-of-the-meter to help large industrial consumers of electricity to minimize their demand charges and avoid disruptions due to brown-outs. Batteries will also provide the storage medium necessary with the many alternative energy sources being developed.

The U.S. Department of Energy is vigorously pursuing the development of a number of advanced battery systems, zinc air and zinc bromine among others, which show promise of meeting the need for energy storage in the distant future. Unfortunately, they have elected to discontinue the funding of research on an advanced system, the nickel hydrogen battery, which could meet those near-term needs when they arise.

The nickel hydrogen system has been proven in aerospace applications. It was initially developed over a dozen years ago for communications satellites. It has long been known that it has a number of attributes which make it very attractive for terrestrial applications as well: very long cycle-life, very high energy efficiency, and no maintenance requirements. These make the system, if it can be fully developed, cost competitive with any other advanced battery system for large energy storage applications. The clear difference is that the nickel hydrogen system can be made available for those applications in the near-term.

Johnson Controls, Inc. of Milwaukee, Wisconsin has been developing the terrestrial nickel hydrogen battery over the past five years. The program's cost has been $3.2MM. We have received funding of $580K during that time through the Department of Energy's Sandia, Albuquerque, Laboratories. This cooperative, cost-shared program between one of the leading National Laboratories and one of the world's major battery manufacturers has been very successful. While Sandia's interest is principally in electric storage for autonomous photovoltaic systems, they anticipate military applications as well.

We are very excited about the prospects for the successful development of this system; but we are unable to justify our continued funding of a program, so far removed from our traditional line of business, at the level needed to make it available.

The further development of the nickel hydrogen battery will require $1.8MM of external funding and three years. The size and importance of the likely pay-off to the Nation are very large. The investment by the government we're requesting is very small.

THE UNIVERSITY OF CONNECTICUT

Institute of Materials Science
Electrical Insulation Research Center
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March 17, 1987

Honorable Wendell H. Ford
U. S. Senate
Washington, D.C. 20510

Dear Senator Ford:

As an honorable member of The Senate Committee on Energy and Natural Resources and the Subcommittee on Energy Research and Development, you are in a unique position to have a significant impact on the shaping of our national goals and strategies regarding science and technology. You may wish, therefore, to learn about the views of a large cross-section of your constituency, so that any important and far reaching decisions you make will properly reflect the perceptions and concerns of those affected by your decisions.

This letter discusses specifically the areas of Science and Technology covered by the Electric Energy Systems (EES) Program, Office of Energy Storage and Distribution, Department of Energy (DOE). I am presently a Professor of Electrical Engineering and Director of the Electrical Insulation Research Center (EIRC) at the University of Connecticut, and have had over twenty-five (25) years of full-time professional experience with the electric power industry. The views expressed in this letter are not confined to the narrow interests of academic research, but embrace the broader aspects of the electric energy needs of the Nation.

The present state of electric energy technology in the U.S. is the subject of serious concern. The energy demand has resumed its increase at an average rate exceeding 2.5 percent per annum. The quality of electricity has been deteriorating while the need for a safe, secure, and reliable flow of power has become more and more imperative because of the vital role played by sensitive electronic devices, such as computers. Several major electric utilities are facing severe financial problems which are compounded by an unresponsive regulatory climate. As a result, equipment orders needed to meet the anticipated demand growth are being deferred. This, in turn, is having several serious consequences:

(a) U.S. equipment manufacturers are no longer investing the research funds to keep up with the advancement of technology

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(b) Some domestic manufacturers are shifting from the production of power equipment to more lucrative businesses such as services and consumer products. The voids thus created are being filled by foreign competitors who are gaining a stronger foothold in the electric energy business.

(c) The Electric Power Research Institute, the research arm of the electric utility industry, is losing a large number of supporting utility members and, thus, is cutting back its own research commitments.

The situation can be best compared to a highly anemic patient who is unable to generate the red cells needed to improve his health. In the case of a patient, it is evident that blood transfusion may be the best and most effective solution. In the case of the U.S. electric energy supply, a similar infusion in the form of research and development funds is the indicated solution. As these funds will not be coming from the private sector, the only hope to effect a reversal of this declining trend is for the public sector to assume its leadership role. The EES Program of the DOE is already in place and its established mission exactly meets the requirements necessary to enhance the security, safety and performance of the Nation's electric energy supply. The EES Program focuses effectively on these critical issues and presents a cohesive, well conceived plan designed to produce the positive results expected.

While the EES Program appears to be the focus of a solution to problems plaguing our electric energy supply, the recent fate of its budget raises serious doubts about its continued ability to accomplish its mission. Since 1980, this budget was reduced from approximately $40 million to slightly over $11 million, thus losing almost 75 percent of its original strength. This loss could not have been incurred without severe cuts in the program, at a time when the best solution can be achieved only by a substantial boost. It is with a great sense of frustration that I observe, daily, a worldwide loss of our competitive edge in these areas of technology where we were once leaders. I am certain, however, that our representatives in Washington, D.C., have not lost their resolve for excellence and that they still regard energy and technology as vital areas in which this excellence needs to be maintained. At EIRC, we are specifically concerned about research on electrical insulating materials. It is through a well funded and steady research program that we can promise to make the supply of electric energy secure, safe, and economic.

I urge you, therefore, to consider boosting the EES Program budget to a level which will allow it to fund all the programmatic areas which are vital to the enhancement of our electric power supply. I realize that you have a difficult task of balancing all the competing needs of the Nation, but I trust that you will give this subject all the consideration it needs and deserves.

Sincerely,

Matthew S. Mashikian
Professor of Electrical Engineering and
Director, Electrical Insulation Research Center

MSM:da

Written Testimony of Carl Avers

International District Heating and Cooling Association

before the Subcommittee on Energy Research & Development of
The Energy and Natural Resources Committee

March 31, 1987

Thank you for allowing me the opportunity to present testimony in support of Fiscal Year 1988 funding for the Department of Energy's District Heating and Cooling research program. I am the President of the International District Heating and Cooling Association and am also President of Catalyst Thermal Energy Corporation which owns and operates district heating systems in Boston, St. Louis, Philadelphia, and Youngstown, Ohio.

I am acting as a spokesman for the International District Heating and Cooling Association (IDHCA), an organization of suppliers and users of district heating and cooling that has promoted this technology since 1909. IDHCA is appreciative of the past research efforts that the federal government has provided, and strongly urges Congress to provide funding in Fiscal Year 1988 for technology research and feasibility assessments aimed at increasing the use of energy-efficient district heating and cooling in the nation's urban centers.

Documentation attached to this testimony describes the significant benefits that district heating and cooling provides to the nation, its cities, and individual consumers. In brief they include:

- Improved energy use efficiency
- Stabilized energy prices to consumer
- Fuel choice flexibility which reduces dependence on foreign energy sources
- Improvements in indoor and outdoor air quality
- Stimulation of urban economic development through private sector investment and creation of employment opportunities.

Most European nations have developed highly efficient district heating and cooling systems, and have structured a political, institutional, and economic environment supportive of the concept. By contrast, in the U.S. DHC has grown only in the large institutional, governmental and university campus setting. Large urban areas have seen continuing decline in the application of community energy systems to meet the changes which have taken place. The urban renaissance is moving American cities again. DHC is a key component of this movement but only in a few of these cities. Federal government support is needed to develop new technologies capable of continuing the improvement of the efficiency and economics of district heating and cooling. Federal "seed money" is also needed to continue the highly successful DOE Feasibility Studies program that has allowed over fifty communities to evaluate the potential for district heating and cooling in their specific applications. These studies have resulted in subsequent public/private district heating development in several instances, and have shown a leveraging factor in excess $100 for every $1 of initial federal support provided.

The International District Heating and Cooling Association urges that funding for district heating and cooling research be provided in Fiscal Year 1988 at a level of approximately $3.5 million, a value similar to the Fiscal Year 1985 appropriation. This will allow the Department of Energy to support a valuable, industry cost-shared program of technology development, feasibility assessment and technology transfer of great importance to the nation.

The Importance of District Heating and Cooling in the U.S. Energy Policy and the Case for DOE Research & Development Funding

District heating and cooling (DHC) is a term used to describe the delivery of heating or cooling energy to multiple building structures via a common distribution system. DHC energy is produced in one or more centralized facilities, often as part of simultaneous electricity production in a process known as cogeneration.

DHC provides a number of benefits to its users, the community, and the nation that makes it attractive when compared with individual building heating and cooling systems. When DHC is combined with electric power production, significant energy savings are attainable; an estimated 2.5 quadrillion Btu's annually in the year 2010. DHC also allows communities to use solid fuels such as coal, biomass, or solid waste as energy sources since they can be burned in an environmentally acceptable manner in DHC central stations. Most importantly, however, the development of technologically advanced DHC is critical to the resolution of a number of interrelated economic development, international competitiveness, energy resource, and environmental problems that are simultaneously and collectively facing America's businesses and industries, cities, and energy utilities. DHC can serve as a magnet to attract and match diverse energy resources with advanced energy conversion systems supplying thermal energy to industries, commerce, institutions and residences at low cost and low environmental impact. DHC technology has the potential to turn some of our most intractable problems into some of our most attractive opportunities for economic redevelopment and environmental renewal. As such, DHC development can become a key element in solutions to the decline in the competitiveness of the American urban economy now being addressed by Congress.

To obtain these benefits, however, DHC must be economically competitive with individual heating and cooling systems. Research and development is needed to reduce development, construction, and operations costs, and to provide for flexibility in energy source utilization. Additional efforts must also be undertaken to assist communities across the nation in understanding and evaluating the potential impacts of DHC when applied to their particular applications.

Most European nations have developed highly efficient DHC systems, and have structured a political, institutional, and economic environment supportive of the concept. By contrast, DHC in the U.S. has declined markedly over the past forty years, and the industry associated with it is very small and fragmented. Federal support for DHC research and feasibility assessment is therefore needed and warranted; both to cost-share development of advanced technologies to the point where private industry will be willing to accept the risk of further development alone, and to provide "seed money" for community use in evaluating DHC technical and economic potential.

Private sector support for DOE's current district heating and cooling research program is extensive and includes considerable industry participation through contributions of materials, facilities, and technical expertise. A sample listing of just a few of the larger U.S. companies working cooperatively in DOE's research endeavors includes: Dow Chemical, Dupont, Owens/Corning, Union Carbide, 3M, B.F. Goodrich, General Electric, Babcock and Wilcox, Thermo-Electron, and CBI Industries. Numerous other smaller manufacturers and engineering organizations also contribute to, and participate in, ongoing DOE research projects.

IDHCA has identified several areas where federal support, in the form of U.S Department of Energy (DOE) research programs addressing district heating and cooling, would provide significant short and long term benefits to the nation. Each of these areas is summarized below under two major headings: Technology Development, and Feasibility Studies.

Technology Development

DHC systems are unique in their ability to offer urban and business industry energy services at low and stable prices. This is possible because a wide variety of lower cost local energy sources can be employed which, for the most part, are not feasible for use in individual building energy conversion systems. Fuels such as coal, biomass and urban waste can be burned in central stations that are sufficiently large to be able to employ economical air pollution control technology. Furthermore, these fuels as well as oil and natural gas can be used as inputs into high efficiency cogeneration processes which generate both electricity and DHC energy at much lower costs than separate electricity and heat production processes.

DHC component and system technology, unfortunately, has not kept pace with advances in cogeneration and our ability to utilize solid fuels. New DHC component and system configurations are needed that are cost effective, much more energy-efficient than current designs, and can take advantage of a variety of novel energy sources. Development of these new components and systems is dependent on research which will adapt advanced materials, electronics, and new thermodynamic principles to DHC applications. DOE research to-date has produced impressive results in a number of areas. Argonne National Laboratory has identified several fluid additives that have the potential to reduce DHC piping size, and hence cost, almost 50 percent by reducing fluid frictional drag and increasing fluid energy capacity. Other DOE research has identified operational principles for an accurate, low-cost thermal energy meter, and characterized a number of non-metallic piping materials which may provide lower cost and extended system life. Current DOE research also includes development of two novel heat pump cycles capable of utilizing low temperature thermal energy sources.

An area of rapidly growing interest worldwide is the development of large-scale district cooling systems. In the U.S., where hot summers are experienced by nearly all urban areas, air conditioning is employed in most large buildings and nearly all urban electric utilities experiences their peak demand for electric power during the summer months. However, despite its potential for providing air conditioning with very high efficiency and excellent economy, district cooling has been the beneficiary of scant amounts of R&D to date. Yet, it is clear from DOE's recent and ongoing work that advanced forms of district cooling technology have great potential for application in the U.S. Futhermore, the export potential for mature district cooling technology is much larger than for district heating, since the bulk of the world's climatically hot areas hold the bulk of its population as well as its most rapidly growing urban areas. Thus, there is a significant incentive to develop advanced forms of district cooling technology not only for our own use but for its export potential as well. America clearly has the opportunity to be at the cutting edge of district cooling technology and to capture the lion's share of international markets.

FY 1988 congressional funding of DOE research on DHC technologies is urged, both to continue the highly promising work now underway and to undertake new research initiatives aimed at improving efficiency and reducing cost. As evidenced by ongoing projects, private industry is willing to cost-share in these initial research efforts during their highest-risk periods and subsequently take over entirely the detailed development of attractive technologies.

DHC Feasibility Studies

In 1980, DOE sponsored its first round of cost-shared feasibility studies, wherein communities across the country could gain federal support in evaluating the technical and economic potential for DHC development. Over a hundred proposals were submitted, and 28 cities were given awards. Of these 28 awards, several have gone on to develop and construct DHC systems utilizing a variety of local government and private sector funding mechanisms. DOE provided grants in 1985 and 1986 for feasibility studies in a total of 27 additional communities. These studies are currently underway. The feasibility assessment program has illustrated the high level of interest in DHC within communities, and community willingness to provide cost-sharing from local and private sector sources. Results from the original 28 city studies also indicated that:

- Potential total investment in the identified projects could be in the range of $500 million to almost $1 billion.
- Total project construction could generate up to 6,700 on-site construction job-years, plus an additional 17,500 off-site jobs.
- As a result of project construction, the cities could expect to retain a grand total of $165 million annually in their local economices.
- The cities expect district heating systems to support their revitalization efforts by helping retain struggling business and industry, improving their competitive position, lowering governmental costs, helping to stablize tax rates, reducing operating costs for housing (particularly public housing), improving air quality, and reducing waste disposal problems by using refuse as a heat source.

The DHC feasibility studies program should continue to receive DOE support. In addition to direct grants to communities, DOE should provide technical assistance during feasibility assessment efforts and carry out technology transfer to make the results of previous feasibility studies available to all communities who may have an interest in DHC development.

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Written Statement of the
Cogeneration Coalition of America, Inc.
On the
Development of Alternative Energy Technologies
Before the
Subcommittee on Energy Research and Development
Of the
Senate Committee on Energy

March 26, 1987

This written statement is submitted on behalf of the Cogeneration Coalition of America, Inc. ("Coalition"), for the record of the hearings before this Subcommittee regarding the development of alternative energy technologies.

The Coalition's membership, which is derived from the cogeneration and independent power community, appreciates the opportunity to comment briefly upon the contributions of the developing cogeneration industry. Although we understand that the primary focus of this hearing is the further development of various renewable energy technologies, we appreciate the opportunity to comment upon cogeneration. We think that it is important to note for the record the significant contributions which cogeneration already is making toward achievement of the national goals of greater energy self-sufficiency and the enhanced competitiveness of U.S. industry.

Conventional Technology vs. Cogeneration.

In recent years, the nation has become increasingly aware that energy costs consume a substantial portion of every corporation's budget. It is axiomatic that improving energy efficiency is an increasingly important and acknowledged way to maximize energy savings and reduce operating costs.

The current inefficiency of conventional electric utility generation means that two out of every three dollars' worth of fuel used to produce electricity ends up as wasted heat. If the electric utilities could use or sell this waste heat, the overall cost of electricity would be reduced dramatically. Unfortunately, most electric utilities have no use for the thermal energy that is produced at their generating facilities.

Also, because of their remote locations, electric utility central power plants typically are just too far from factories, commercial facilities and health or other institutions to supply them with waste heat or unneeded steam for productive uses. At the same time, electricity costs are continuing to escalate for many industrial and other energy consumers, representing a growing portion of their operating budgets. So the question frequently arises -- what can be done about it? Is there another way? In many cases, the answer is yes, through cogeneration.

Although new technologies are evolving, cogeneration is not a new or exotic process and many systems are on line and operating reliably today. Cogeneration is the sequential production of electrical energy and useful thermal energy from a single energy source. In most cases, the fuel's energy is used to produce electricity, and the thermal energy that is recoverable from that process is employed in a variety of other uses. The overall efficiency of some cogeneration systems surpasses 80% in converting fuel to useful energy. This capability is quite substantial when compared to the normal delivered electrical efficiencies, which range from 30% to 35%.

Unlike the central power plant, a cogeneration unit is located near a user of heat and power, and the heat rejected in the exhaust gases or cooling water is used to satisfy some thermal requirement. On-site cogeneration means working one fuel twice.

Cogeneration Is Well Established And Has Much Promise.

Although cogeneration has offered substantial energy savings for many years, passage of the Public Utility Regulatory Policies Act ("PURPA") in 1978 created a favorable climate for new investment opportunities in these systems. Prior to the assurance of guaranteed interconnection and standby service, made possible by PURPA, facilities with cogeneration had to install oversized systems to insure 100% self-sufficiency. Since passage of PURPA, many corporations and institutions have begun to explore plans to benefit from the potential energy cost savings made possible through the installation of cogeneration systems.

Cogeneration offers particularly significant potential for the nation's troubled heavy industries. Through the substantial savings made possible by cogeneration, energy-intensive industries can lower their costs and improve their competitive position in the world market. For example, one of the first major industries to recognize the benefits of the technology has been the American paper industry. In describing the recent revival of that industry, a Wall Street Journal article made this observation:

> One key aspect of the paper industry's self-improvement has been the switch to cogeneration. Indeed, paper was among the earliest industries to recognize the savings in switching from traditional electrical use to cogeneration, which produces electricity and steam heat from a single fuel source such as coal, natural gas or wood chips. Paper manufacturing is a very energy-intensive industry; last year companies spent more than $2 billion to buy some 40 trillion kilowatts of electricity, according to [the American Paper Institute]... [1]

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[1] The Wall Street Journal, Oct. 30, 1986, at 6.

The greatest potential for cogeneration traditionally has been represented by five major sectors of the economy: food, pulp and paper, chemicals, petroleum refining and primary metals. But, increasingly, these industries are being joined by others, as well as by schools, colleges and universities, banks, restaurants, hotels, hospitals and other institutions. Also of increasing significance are municipal resource recovery plants, which also offer the opportunity to solve our solid waste disposal problems for the future. Cost controls and momentum for cost containment also are generating new pressures to pursue cogeneration projects in varied commercial applications.

Various estimates indicate that technical cogeneration market potential could range from 20 to 50 Gw of new power by the year 2000. [2/] Actual penetration will vary, depending upon the maintenance of a stable development environment under PURPA, the implementation of necessary state laws and policies, and the federal tax policy by which financing of such projects can be sustained. Precise information is not available, but our members estimate that the cogeneration market currently represents about 7% of the total electricity produced in the U.S. It is predicted that this market could increase to over 15% by 1995, with varied levels of penetration by region and by industry.

It is clear that additional electricity supply is likely to be needed in the 1990's. [3/] Particularly given the nation's aging capacity, a renewed commitment to cogeneration and all alternative energy technologies is required if an optimal and efficient mix of electricity supply is to be available in the next decades. In preparing for the future, the nation as a

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[2/] U.S. Dept. of Energy, Energy Security; A Report to the President of the United States, at 142 (March, 1987).

[3/] *Id*. at 136-9.

whole cannot afford to rest on the recent collapse of world oil prices and ignore the continuing need to promote energy efficiencies.

Energy efficiency through cogeneration can assist in the displacement of imports of foreign crude oil. Another factor is that a large share of the excess capacity in the U.S. electric system today is comprised of unused and available oil-fired generators. Once the limited capability of new power sources now planned or under construction is exhausted, the nation's utilities are likely to begin to turn to oil, once again, as a major source of new generation. Further development of cogeneration and other alternative energy resources can play a vital role in heading off a substantial increase in the use of oil to generate electricity.

State and federal policymakers are becoming increasingly aware of the fact that promotion of cogeneration can yield increased energy efficiencies and facilitate demand-site load management. In so doing, cogeneration offers an opportunity to better match individual energy systems with customers' load requirements, which is typical of energy load management objectives in utility planning for the future.

Although there are inherent limits to the number of situations in which cogeneration's benefits can be made available, clearly the potential for cogeneration development has not yet been fully tapped. Further development should be fostered by sound, consistent energy policies and improved economics resulting from stable federal regulatory and legislative environments. In particular, it is important that the Congress continues to support the full implementation of PURPA.

Cogeneration Offers Many Benefits.

Cogeneration already is offering a wide range of benefits to energy users, to ratepayers, and to the nation as a whole. To summarize, we would like to list just a few of those benefits:

°Accelerated construction of cogeneration facilities, compared to traditional baseload generation plants, ensures faster and more flexible servicing of short-term increases in electricity demand. Because cogeneration technology permits the addition of small increments of electric capacity to a utility system and requires shorter construction lead times, the risk of over-building is reduced.

°The development of cogeneration reduces the risks of system-wide electricity failure by dispersing electric utilities' sources of power. Varied and dispersed sources of electricity can contribute to maintenance of a reliable total system.

°With cogeneration development, the financial health and financial ratings of electric utilities could be improved because of a reduction in capital requirements. Construction costs per kilowatt of a typical cogeneration facility are currently less than half the costs of new conventional coal or nuclear capacity. Furthermore, with cogeneration, costs and risks of construction are shifted away from utilities -- and ratepayers -- to the private sector.

°Cogeneration development permits optimal decision-making by utility planners regarding the expansion of generating capacity and the replacement of older, less efficient powerplants. Through cogeneration, utilities can decrease fuel costs, and ultimately reduce consumer rates. Increased industrial and commercial use of cogeneration, which will be fostered by vigorous implementation of PURPA, will provide least-cost, diverse power supplies, improved reliability, and more efficient use of limited energy resources.

°The financial and service benefits of cogeneration are derived at costs to the ratepayer no higher than the electric utility would itself have paid to generate the same unit of energy. Since full avoided cost rates are based upon the electric utility's own data on the cost of its alternative sources of electricity, various recent claims of "subsidization" or increased rates clearly are unsupportable.

Moreover, if accurately calculated, avoided costs could effectively become the benchmark against which all electric power supply options ultimately are judged.

°Steady additions of cogeneration can maximize ratepayer benefits by reducing avoided costs and, in turn, overall costs of power. As systems are supplemented by alternative energy producers, the marginal fuel for these systems will cease to be strictly oil or natural gas.

°Reduced fuel usage through cogeneration can improve air quality and foster reduced costs of environmental compliance for the electric utility and its ratepayers. Depending on the type of cogeneration system installed and the fuel used, the operating efficiency of cogeneration leads directly to a net decrease in total emissions to the air.

°Increased use of cogeneration facilities will reduce the need for costly energy subsidies traditionally enjoyed by the electric utility industry and passed on to ratepayers. Reduced requirements for construction work in progress, allowances for funds used during construction, and normalization of taxes will lessen the level of such subsidies, which exceeded $50 billion for the fiscal year 1984 federal budget. Displacement of these subsidies by increased use of cogeneration will lessen the federal tax burden on ratepayers and ease pressure on the federal budget deficit.

°Deployment of energy-efficient cogeneration can result in reduced reliance upon imports of foreign crude oil. The major share of the excess capacity in the U.S. electric system is comprised of unused oil-fired generators, and, absent alternatives, the nation's utilities are likely to begin to again use oil as a major source of new electric generation.

°Energy cost savings through cogeneration can increase the competitive position of U.S. industry. The experience of the paper industry demonstrates the vital role cogeneration can play in strengthening a troubled industry.

Conclusion.

The Coalition appreciates the opportunity to offer these comments, and stands ready to work with the Subcommittee as it continues its review of the important benefits made possible through the continued development of alternative energy technologies. Furthermore, we urge that the Committee, as it considers ways to foster a healthy alternative energy industry, take note of the vital role which PURPA has played and must continue to play.

Respectfully submitted,

Michael J. Zimmer
President

BEJ6/4000

SEIA

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TESTIMONY

by

Scott Sklar
Executive Director

before

Senate Energy & Natural Resources Committee
United States Senate
Subcommittee on Energy Research & Development

March 24, 1987
Washington, D.C.

INTRODUCTION

While U.S. petroleum imports climb precipitously and contribute to the staggering U.S. trade deficit, U.S. policymakers remain complacent about the dire need to develop a national energy policy. The United States is the only industrialized country without an aggressive energy strategy to protect our economy and national security.

While the U.S. cuts its energy research budgets for both conventional and renewable energy technologies, our international competitors are increasing their federally-sponsored R&D in great anticipation of controlling the high-technology world energy markets in which the U.S. appears to have little interest. However, while Washington seems preoccupied with "competitiveness" issues, energy issues are somehow shuttled to the side of the trade discussions.

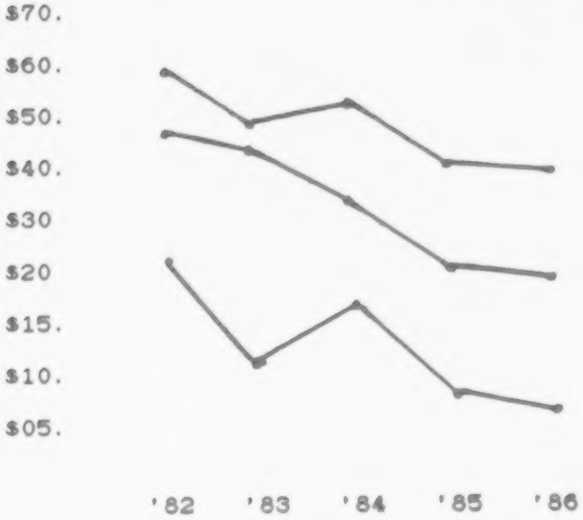
In 1985, the U.S. Department of Energy released a "white paper" which related that the United States, between 1975 and 1985, spent $4 billion dollars for solar and renewable energy R&D, and $2 billion for tax incentives. As a result of this R&D, the report states further, over $36 billion of petroleum was displaced by solar and renewable energy applications resulting from our government's effort. In 1987, the United States has a choice to maintain its minimal solar energy effort or to reliquish its lead to our international competitors who are preparing to control the potential multi-billion dollar world market in the 1990's.

The U.S. solar industry asks the Congress to take notice of our young American industry and give us a chance to reach our potential to provide domestic energy to offset petroleum imports in an environmentally benign fashion. Most importantly, solar energy will be an energy resource of the future, and the real question is which countries will lead technologically and thus reap the market benefits of the future?

BUDGET REVIEW

Before I begin a technological review of the U.S. Department of Energy (US-DOE)R&D budget, I have shown in a graph below the decrease in the U.S. solar energy (ie. solar buildings, solar thermal power and photovoltaics) budget over a five year period:

TRENDS IN FEDERAL SOLAR R&D



Side axis: Dollars are expressed in millions of dollars.

Bottom axis: The top line is US-DOE photovoltaics budget, the middle line is US-DOE solar thermal power budget, and the bottom line is US-DOE solar buildings budget.

As you can see, the federal commitment for solar has dropped to a point where if the budget goes any lower, the U.S. research effort would be meaningless. The United States must maintain level funding and work with the Office of Management & Budget (OMB) to incorporate the U.S. solar R&D funding effort in a two-year funding cycle to insure some kind of stability. Otherwise the small U.S. solar R&D effort will be subsumed by those of our competitors before the 1990's.

THE US-DOE SOLAR PROGRAM

I have attached to the testimony a draft set of recommendations which the industry will present in a modified version to the U.S. Congress at the appropriate Congressional appropriations hearings later this month. The following capsulets of the three basic solar industry R&D programs including the premier national laboratory, the Solar Energy Research Institute (SERI), and the international program are presented below.

International: The current US-DOE program was funded in FY'87 at $.8 million and industry in FY'88 is recommending an increase to $1.5 million. Most of this appropriation goes to fund the activities required under P.L. 98-370 which established the federal interagency working group chaired by the U.S. Department of Energy called" The Committee on Renewable Energy Commerce & Trade (CORECT)". Since a good portion of solar sales are export sales, these activities providing information, federal agency coordination, and development of generic market activities are absolutely vital. The U.S. Departments of Energy and Commerce, as well as the Agency for International Development deserve much credit for the success so far. And because of this success, this small program should be broadened to be more effective. Activities for 1987 include the hosting of a PV in Development Conference in May for potential buyers from multinational aid and development organizations as well as other marketing programs. The FY'88 funding year will provide crucial assistance in developing greater support among banking & financial institutions for renewable energy exports and key market promotion activities in the Caribbean Basin and the Pacific Rim nations.

PHOTOVOLTAICS: In FY'87 PV R&D was funded at $40.4 million, and the industry in FY'88 recommends $43.1 million plus an extra $7.5 million for a broad-based utility application (PV-USA). As stated in SEIA's earlier testimonies to this Subcommittee, over 75 percent of the world's population does not have access to electricity. The World Bank is directing most of its $6 billion per year of energy funding towards diesel electric generation for the developing world. However larger proportions of international bank financing are moving towards renewable energy, particularly photovoltaics. Although the costs of photovoltaics have come down ten fold over the last decade, PV technology is still higher than conventionally-generated electricity today. However, most in the industry believe that PV's will become completely competitive in 1990's in the U.S. energy markets which are lower than the rest of the world.

An essential ingredient in whether PV's will meet these cost reduction estimates relies on the status of the current US-DOE research program. The move from single and multicrystal silicon to amorphous silicon deposition has the potential to significantly bring down costs. The amorphous silicon and thin film research efforts are directed towards this end. The other key component to meet cost and reliability requirements are to better integrate the PV technology with power conditioning equipment and the end-use equipment. The collector research and technology diffusion line items assist industry in this regard.

The US photovoltaics industry held 80 percent of the world market just four years ago. Today, the US PV industry has barely half the market while the Japanese are reaching for world dominance in the technology. In 1985, the Japanese for the first time surpassed the United States in photovoltaic module production. Only a solid R&D program which continues its high-efficiency and fundamental research will maintain the US technological lead. The core program, as recommended by the US industry must be maintained at a $43.1 million for FY'87 if the US is to maintain its pre-eminence in this high technology of great promise.

In addition to the core $43.1 million, the industry is recommending an additional $7.5 million for a set of US utility applications throughout the United States to monitor technology in the real world. The newest PV technology and power conditioning equipment, must have the necessary system testing around the nation before PV technology can be procured by the utility industry when cost effective in the mid 1990's.

SOLAR BUILDINGS: Over 36 percent of our nation's energy is used to heat or cool space or water for buildings yet the greatest amount of R&D monies goes towards electric generation. In FY'87 the US-DOE solar buildings program was funded at $5.9 million and in FY'88 the U.S. solar industry strongly urges that it be raised back to its FY'86 levels of $7.2 million. In 1985, this budget was cut precipitously at the request of OMB because the industry had tax incentves, but by the end of the year, the Congress did not extend these tax incentives and over 100 solar manufacturers and a total of 30,000 people lost their jobs. And as the United States undercuts their own solar heating industry, again our international competitors are increasing their federal support to fill in the void left by the United States.

The solar buildings budget is excrutiatingly small and focusses on two discreet areas. First, the aperature & building surface materials and system research line items maintain U.S. prominence in the passive solar technology. This technology which incorporates building design and materials for low cost ways to produce and save energy has become a new high technology area. The Swedish government and industry have become world leaders in this technology which will become a prime export commodity for them. The U.S. program will maintain the U.S. lead in this prime area of opportunity by developing a federal/industry/university partnership in several research areas. Second, the chillers, thin film, and evacuated tube line-items are the culmination of bringing advanced technologies research out of theory to a testing and evaluation stage. Indeed, it is these new kinds of technologies that may allow the U.S. to hold a lead in the active solar energy field.

While the solar buildings budget gets severely lopped off every year, U.S. building energy usage is still high, and our international competitors are building their technological competence in order to more effectively compete against us by using the research that was originally funded by the American taxpayer.

SOLAR THERMAL POWER: The technology which focuses sunlight to create high temperatues for industrial process heat or steam for electricity has reached the marketplace. Over 100 megawatts of generation are currently in California with more than twice that amount expected to be "on line" over the next two years. In FY'87 the US-DOE R&D program in this area received $22.9 million and for FY'88, the U.S. solar industry is recommending $28.6 million. The solar thermal power industry is at a crucial stage of transfering research from the laboratory stage into the marketplace, evaluating the technology, and recommending further research.

The potentials of this technology has been overlooked and underestimated by energy policymakers. Solar concentrators have been one of the most efficient technologies for electrical generation and industrial process heat. The micro-utility applications will make this technology more appealing throughout the world. The United States holds a technological lead though the Soviet Union and others are gaining. The greatest cost reduction appear to be the development of lower cost concentrators using stretch membranes, lenses, and other materials.

Thus the collection technology line-item is critical to finish this positive research towards lower cost collectors. The systems technology research line-item is also essential if the U.S. is to effectively integrate this new technology into the conventional utility network. The U.S. has made a substantial investment in this technology and the U.S. industry, in consultation with the U.S. Department of Energy and university community, has developed a five year plan. This five year plan is significantly higher than current appropriations levels and should be adopted as the basis for the American effort to develop this technology.

OVERVIEW OF THE US SOLAR INDUSTRY

By any means, the U.S. solar energy industry is small particularly compared to the conventional energy industries. In 1986 sales for photovoltaics is believed to reach $350 million with over half being exports. In 1986 sales of solar thermal power equipment surpassed $100 million with most of the technology being installed in large utility projects in California. Sales in 1987 are expected to rise significantly. In 1986 sales for solar space & water heating equipment fell dramatically from $900 million in 1985 to $325 million.

In the photovoltaics industry, two industry giants are no longer manufacturing. Solavolt, a joint venture of Motorola and Shell, have closed down their operations, while Mobil Solar Corporation has announced its intention to continue research but not marketing. While manufacturers are thinning, PV packaging and marketing companies are increasing--selling everything from solar-powered street lights to remote, turn-key electric generators.

In the solar heating & cooling industry only twenty major manufacturers exist from over one hundred in 1985. Sales are beginning to rise mostly in the solar hot water heating retrofit and new housing markets. Attempts in federal procurement and exports in 1987 should expand sales slightly. As the solar equipment comes down in cost and the distributor markets are rebuilt, the U.S. solar industry should get back on its feet in 1988.

In the solar thermal power industry, the utility market remains the greatest opporunity. Major projects will be consummated throughout the United States. As long as the U.S. R&D commitment is maintained, this industry should expand most rapidly in domestic applications with more companies involved in all aspects of manuafcturing, sales and installations.

CONCLUSION

To summarize basic industry recommendations, funding levels ought to be stablilized through two year funding cycles with the following appropriations levels for FY'88:

International	$1.5 m
Photovoltaics	$43.1 m
PV-USA	7.5 m
Solar Buildings	$7.2 m
Solar Thermal Power	$28.6 m

In addition, the premier federal solar research laboratory, the Solar Energy Research Institute (SERI), must receive its own line-item (beyond capital equipment). This approach will insure stable funding for SERI as well as provide effective oversight for both Congress and the industry as to how much support from each line-item program actually goes to SERI. SERI must be strengthened and maintained as the central focal point of federal laboratory activities in solar energy.

Finally, the U.S. Congress must establish an national energy policy that focusses on the development of domestic resources in an environmentally sound way. Such a policy must clearly promote those technologies the U.S. has developed through years of government research and support. Solar thermal and electric technologies must be an important part of such a policy. If the United States fails to retain its research programs, the U.S. will be overtaken in these technologies and ultimately lose the multi-billion dollar markets of the 1990's. The choice is clear--to remain competitive the United States must look towards the future, and the U.S. solar energy industry urges the U.S. Congress to do so.

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STATEMENT OF HERBERT M. BOYD

Submitted to the
Subcommittee on Energy Research and Development
of the
Senate Committee on Energy and Natural Resources

April 3, 1987

Mr Chairman, members of the Subcommittee, I am Herbert M. Boyd, Technology Management Coordinator, Alabama Power Company, a subsidiary of the Southern Company. I appreciate this opportunity to present an electric utility industry view on the need of adequate funding for the Department of Energy's photovoltaic research and development program. The proposed funding, in the FY 1988 budget, of $20.4 million is not adequate to meet the basic needs for photovoltaic research and development. I recommend a minimum of $43.1 million during FY 1988 for core research programs plus $7.5 million, as a separate line item, for PV USA.

Alabama Power Company's Involvement in Photovoltaics

Alabama Power Company, at its own expense, has built and put into operation the world's largest amorphous silicon thin film photovoltaic grid connected array. This $1 million, 100 KW demonstration unit produces enough power at the time of our system peak to meet the needs of 25 homes. In addition, Alabama Power Company management represents another subsidiary of the Southern Company, Southern Investment Group, in its joint venture with Chronar Corporation to develop a 1 MW amorphous silicon photovoltaic cell manufacturing facility in Birmingham. The Southern electric system is investing $6.1 million in the manufacturing facility which will begin operation before the end of 1987. Alabama

Power Company has made these commitments to photovoltaics because it believes the direct conversion of sunlight to electricity is one of the promising options to help meet the electric demand of the country in the 1990s and beyond.

Photovoltaic Industry

The photovoltaic industry is still very small compared with other high technology industries and profitability is virtually non-existent. It is estimated that during 1986 worldwide revenues from the sale of 27.5 MW of photovoltaic modules was $250 million and the United States had only 27% of the market. The small revenues of the domestic industry cannot support the necessary research to develop the scientific foundations upon which a large scale industry can grow. The partnership between DOE and the industry has produced increased conversion efficiencies and reliability. These improvements have reduced costs from $10,000 per KW in 1980-1982 to $6,000 per KW in 1986. Continued DOE support is needed for research to reduce costs further before photovoltaics can compete with other energy sources. The United States is still a long way from meeting the goal set out in the Solar Photovoltaic Energy Research, Development and Demonstration Act (P.L. 95-590) of producing 2,000 MW annually by 1990 at an average cost of 15 cents per KWH.

DOE Research and Development

Private industry and DOE have had a long and successful partnership in developing photovoltaic energy systems. However, recent reductions and proposed further cuts in DOE's funding of photovoltaic research and development is creating serious problems in the domestic industry's leadership in photovoltaic technology. DOE's funding for research and development increased from $3.5 million in FY 1974 to $150 million in FY 1980. However, since 1980 there has been a sharp downward trend in DOE funds for photovoltaic research and development, and for FY 1986 and FY 1987 it was $40 million. The proposed funding in the FY 1988 budget of only $20.4 million is not adequate to meet the basic needs for photovoltaic research and development if the United States is going to be able to successfully compete for sales in the domestic and overseas markets.

Foreign Competition

United States producers of photovoltaic cells have concentrated their research efforts on developing technology for commercial photovoltaic units while the Japanese have taken the lead in consumer units for watches and calculators. However, as shown in the following table, United States shipments of commercial cells since 1983 have been declining while shipments by other countries have been increasing. The United States share of the world market for commercial units fell from 64% in 1983 to 33% in 1986 and Japan overtook the United States in shipment in 1986. Europe, India and other countries have also increased their share of the world market on both an absolute and relative basis.

World Photovoltaic Commercial Cell Shipments
(MW)

	1983	1984	1985	1986
United States	9.3	8.4	7.5	7.2
Japan	2.8	5.3	6.4	8.2
Europe	2.2	2.9	3.7	3.4
India/Other	.3	.8	1.8	3.2
Total	14.6	17.4	19.4	22.0

World shipments of consumer modules have followed the same pattern from 1983 to 1986 with United States shipments falling from 3.8 MW in 1983 to .3 MW in 1986 and foreign shipments increasing from 3.3 MW to 5.2 MW during the same period.

The potential world market for photovoltaics is great and the United States needs to maintain a strong research base to remain competitive in the world and domestic markets. The projected world market should increase from 27.5 MW valued at $330 million in 1986 to 150 MW valued at $1,350 million in 1991. Other countries are expanding their photovoltaic research activities. If we do not maintain a sufficient funding for our research programs, it is clear that Japan and the other countries will gain a competitive advantage and the United States will become buyers, not sellers, of the technology in the world market place.

Recommendations

In order to keep the United States competitive in the domestic and world markets for photovoltaics, we recommend a minimum FY 1988 appropriation for DOE of $43.1 million for core research programs, plus $7.5 million for PV USA. The funding for PV USA should be a separate line item in the appropriation. Following are our specific recommendations for funding DOE's photovoltaic research and development programs in FY 1988 and the appropriations for FYs 1986 and 1987.

Photovoltaic Research and Development
(Millions of Dollars)

Program	FY 86	FY 87	FY 88 Recommendation
Material Research			
1. Amorphous silicon thin films	9.4	8.0	9.5
2. Thin films	3.9	5.0	8.5
3. High efficiency research	7.4	6.0	7.7
4. PV fundamental research	4.3	5.0	4.0
Collector Research	6.6	4.5	10.0
Technology Diffusion	3.1	1.6	2.0
System	4.4	9.3	-
Capital Equipment	1.2	1.0	1.4
Core Programs			$43.1
PV USA			7.5
TOTAL	$40.3	$40.4	$50.6

I want to thank the Subcommittee for supporting the photovoltaic research and development programs during the past years. Also, in closing, I would like to stress that it is society's responsibility to insure adequate and efficient technologies are available in the future to meet its energy requirements. Research dollars are required today if we want this to occur by the 1995-2000 timeframe. We, the electric utility industry, are looking to you to provide continued direction and incentive for the research that needs to be done in photovoltaics. The best statement you can make to our industry is that Congress will continue to support the development of new energy producing technologies.

Thank you very much.

SCPV MANUFACTURING FACILITY

- Manufacturing process utilizes the Chronar Corporation technology.
- Process is high tech.
- Employment for three shift operation: 80-90 with 80% being unskilled
- Annual output capability: 1 MW
  (energy to supply approximately 250 average homes)
- Annual glass consumption: 300,000 sq. ft.
- Manufacturing area required: 25,000 sq. ft. of manufacturing space
  5,000 sq. ft. of office space
- Cost of Facility - manufacturing equipment and technology - $7.2 million
- Cost of Building - approximately $2.5 million
- Products - consumer and power modules
- Expansion possibilities - Chronar must spend $3 million per year to develop a flow-line plant. Should this effort be successful Southern Investment Group (SIG) has the right to purchase a plant up to 200 MW in 20 MW stages. While it is expected that the flow-line plant would not be as labor intensive as the current plant, additional employment as a result of the new plant will occur and the output of the plant will mean that a number of related industries will have to be developed (i.e. glass manufacturing facilities, metal fabricating plants, distribution centers, rubber and plastic related facilities.)
- A core business with the requirement of a number of satellite firms.
- Provides a high tech base for other high tech firms.
- Export Business: Manufactured in Alabama sold external to state.
- Will stimulate additional research funding in the area.
- Will attract visitors from all over the world.
- Will utilize local companies to supply raw materials.

RENEWABLE RESOURCES: PROMISES AND CHALLENGES

WRITTEN TESTIMONY
FOR THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON ENERGY AND NATURAL RESOURCES

by

Harvey Drucker
Associate Laboratory Director
Energy, Environmental, and Biological Research
Argonne National Laboratory
Argonne, Illinois

Hearings held on:

Tuesday, March 24, 1987
Thursday, March 26, 1987

March 27, 1987

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RENEWABLE RESOURCES: PROMISES AND CHALLENGES

Renewable energy technologies have natural appeal for all sorts of people--economists, environmentalists, engineers, scientists, members of Congress, and citizens (especially when energy costs are rising). The reasons for this enchantment are rather simple. Everyone loves a bargain; the promise of something for nothing. Also, energy technologies based on fossil fuels and nuclear fission and fusion seem to involve environmental and public health problems that appear difficult to assess and solve. Technologies that use nature's most simple gifts--sunlight, rainwater, persistent breezes--somehow seem benign by comparison.

Unfortunately, renewable resources as a group are not easy to exploit. They tend to be geographically arbitrary (e.g., hydropower and geothermal resources) and therefore not necessarily near key energy users. They can be low in power density and contingent on season or even time of day (e.g., solar power and wind power) and therefore require much more effort to harvest, transport, and store. They do not always come in forms easily integrated into existing systems. Conversion of renewable resources into useful energy may sometimes require large amounts of energy--so much that the energy balance may not be particularly favorable. Almost as much energy is put in as taken out. Further, these technologies are not always ecologically benign. For example, continuous cropping for biomass production has been described by some as "soil mining"; that is, stripping the soil of nutrients, followed by something akin to desertification.

This last paragraph may appear out of place in what will be seen as a call for further research, development, and deployment of renewable resources. This testimony simply states some of the problems facing this family of technologies; problems that we believe are solvable given appropriate time, money, and effort. If the solutions are then transferred to the private sector, renewable energy resources will fulfill those intuitive appeals (i.e., low cost, ready availability, and environmental acceptability).

This testimony discusses a number of matters that could help to advance the cause of this gentle gift of renewable energy. Discussed are present contributions of renewable resources to the U.S. energy balance, potential methods for deriving renewable energy from a variety of sources, modes to effectively and cheaply store this energy, and modes of transmission that would allow energy to be produced where geography and climate are optimal and used where most needed. Also considered are the potential of these technologies, present and future, to contribute to the nation's industrial competitiveness and economic well-being.

POTENTIAL FOR RENEWABLE TECHNOLOGIES

It is estimated, if we include hydropower, that about 10% of the U.S. energy requirement is currently supplied by renewable technologies. Installed capacity in the United States for renewable energy technologies includes the following:

- Solar thermal systems for generating electricity provide 110 MW (existing contracts, when completed, will bring the total electricity generated to 550 MWe).
- Biofuels supply approximately 2.8 10^{15} Btu, or about 4% of the U.S. energy supply (primarily from burning wood).
- Wind turbines have an installed base of generating capacity of 1400 MW.
- Photovoltaic systems are being deployed at rates in excess of 20 MW/year.
- More than one million buildings employ passive solar features.
- Solar hot water systems number more than 800,000 [U.S. Department of Energy (DOE) estimates that 0.2 10^{15} Btu will be supplied by these systems by the year 2000].

ROLE OF RENEWABLE ENERGY TECHNOLOGIES IN U.S. TRADE

Although considerable progress has been made in past years and systems are being installed and operated for energy production and supply, the United States has begun to slip from its position of leadership in renewable energy technologies. It has begun to import renewable energy designs and systems. For example, both Sweden and Japan are exporting prefabricated solar homes to the United States. In the area of solar hot water systems, designs and systems imported from Japan, Australia, and Israel are increasing their market shares. Many of the wind turbines being installed in the United States are being imported from Europe. Solar thermal generation of electricity was initially developed in the United States. Recently, however, concentrating solar collectors manufactured in Israel have taken the lead in this form of electrical power generation.

Photovoltaic technology is an area in which the United States has held a commanding lead because of developments associated with the space program. A very large market for photovoltaic systems is projected, particularly in developing countries that do not have well-developed central power generation systems. The U.S. lead is eroding as Japan has accelerated its development activities at the same time that the United States has been cutting back.

NEED FOR RESEARCH AND DEVELOPMENT PROGRAMS

The several research areas discussed below appear critical for the timely and economically successful development of renewable energy technologies.

Biofuels

Biomass and municipal waste are exploited for energy production, primarily by direct burning. Further research on biofuels and municipal waste technologies is needed to use these abundant materials in a wider range of applications. With proper research, liquid and gaseous fuels could be made from biomass and from the organic content of municipal waste. Fuels that could be produced from these resources include alcohol, biocrude oil, plant-oil-derived gasoline and diesel substitutes, and gaseous fuels. Argonne National Laboratory (ANL) is continuing to play a major role in research and development concerning the use of municipal wastes. Conversion of waste to energy is truly economic alchemy, for a problem (trash) is converted into a benefit (fuel).

Ocean Thermal Energy Conversion (OTEC)

Producing electricity and fresh water by exploiting existing temperature gradients in the deep ocean through ocean thermal energy conversion (OTEC) technology has significant potential for island communities. To achieve the cost goal for OTEC of $3200/kWe, ANL has developed a technology base program and has performed system-level technology studies. Argonne has provided experimental measures, developed model systems and verified their performance. Development of improved and potentially cost-effective components and concepts (e.g., hybrid cycles that produce both power and water) should continue to be emphasized.

Energy Storage

One of the primary goals in renewable energy research is to convert diffuse power sources, such as sunlight, into concentrated power sources that are sufficiently intense and portable to replace fossil fuels in vehicles. In this regard, questions of energy storage (as in research, design, development, and evaluation of electrical batteries) are critical. The concept of vehicles powered by batteries is not new, dating back to the 19th century. However, the prospect of actually achieving needed battery performance to meet the modern demands of transportation applications is new. To significantly reduce the use of oil in transportation, electric vehicle batteries must meet requirements such as vehicle range, acceleration, and consumer utility. The performance of the low-temperature, aqueous electrolyte batteries now available or under development is inadequate. Therefore, ANL's battery research focuses on advanced batteries requiring development of new electrodes and electrolytes.

Within DOE-Conservation and Renewable Energy, two entities fund ANL's battery research and development program: the Office of Energy Storage and Distribution (OESD) and the Electric and Hybrid Vehicle Propulsion (EHP) Division within the Office of Transportation Systems (OST).

Argonne's Advanced Battery Research and Development Project is funded under the Energy and Water Appropriations Act through OESD. The electrochemical technology research being conducted for OESD is critically important to establishing a technology base for solving national energy problems and for ensuring that American industry is technically competitive. Expanding this electrochemical research into areas of corrosion prevention, biomedical devices, and high-performance coatings will result in important contributions to the nation's economic well-being.

Argonne's Lithium/Sulfide Electric Vehicle Battery Research and Development Project is funded under the Interior Appropriations Act through OTS-EHP. This project emphasizes development of battery technologies that will lead to introduction of electric vehicles into the nation's transportation fleet.

Major expansions in funding levels beyond FY 1987 for both the OESD and OTS-EHP programs can be justified on the basis of their future benefits to the nation. At a minimum, these programs should receive sufficient funding to continue at present levels of effort.

Battery research at ANL takes the form of a well-recognized, technically innovative research and development program that has been active since 1972 at significant funding levels. The program has resulted in five IR-100 awards, numerous important patents, and valuable spin-off technologies for military applications. (Several types of batteries based on ANL research are now militarily deployed.)

Technological advances in the past year have resulted in experimental battery cells achieving long cycle life (400 cycles) and outstanding energy and power. Calculations based on using this technology in a revolutionary new battery design indicate higher energy and power (200 Wh/kg and 300 W/kg) than any battery now under development. This battery may be able to provide the vehicle performance demanded by the American public.

The United States is not the only nation involved in battery research and development. Advanced sodium-sulfur batteries are being developed in major research and development programs in Germany at Brown, Boveri & Cie; in England at Chloride Silent Power, Limited; and possibly in Japan. No advanced battery programs of comparable size are operational in the United States. Projects proposed by ANL for FY 1988 will result in batteries that are superior to the systems now under development in foreign countries. Successful development of advanced batteries for transportation could result in renewed U.S. domination of the automobile industry.

New Superconducting Materials: Opportunities in Energy Storage and Transmission

The very recent discovery, both in the United States and elsewhere, of materials that are superconducting at temperatures as high as 90-98 degrees Kelvin is potentially revolutionary. Superconducting materials offer no resistance to the flow of electrons and can therefore transmit electricity without any loss of energy. These materials may be the basis of new energy transmission and storage technologies--technologies of such efficiency that they could revolutionize the organizational and economic matrix of electrical power production and distribution. They could allow seasonal or low-density power sources to be used as necessary in a cost-effective manner. The availability of superconductors may strongly affect the design, development, and economics of existing electrical equipment such as motors, generators, and electromagnets. Furthermore, high-temperature superconductors may enable new technologies, such as magnetic levitation of vehicles and magnetic separation of polluting species (e.g., sulfur) from coal to be economically feasible.

Past efforts to use superconductors in a wide variety of applications have been hindered by the need to cool the known superconducting materials to almost absolute zero (approximately 2-4 degrees Kelvin). Until recently, the highest superconducting material temperature ever attained was 23 degrees Kelvin. These low temperatures require the use of liquid helium as the coolant. Engineering practical helium systems is both difficult and expensive.

In the past few months, a newly discovered class of superconducting ceramic materials has come under intense investigation throughout the world. These materials, which are superconducting above 90 degrees Kelvin, have the potential to reduce refrigeration costs to a fraction of what they have been with previous superconductors and may make many new applications economically feasible.

The promise of these new materials can only be realized, however, through a technology development program aimed at putting them to work. Argonne has recently outlined for DOE a national program on superconductor development that builds upon recent basic science discoveries. The extensive ceramic materials fabrication and components development capabilities at ANL and other national laboratories, as well as at universities and in industry, would be utilized in this research program.

The proposed program is a multiyear effort at a funding level of approximately $4 million per year, which will focus on rapid development of the building blocks necessary for applications, including exploration of various fabrication routes to optimize the properties and current-carrying capabilities of the superconducting ceramics and development of conductors with the metallic coatings and substrates needed for different applications. In parallel with such efforts, economic and systems analyses will be performed to develop conceptual designs for practical applications and to identify the applications with the most favorable economic impact. As ANL builds on these results, development efforts will be directed toward such applications as transmission lines, energy storage devices, generators and motors, and other electromagnetic devices that appear especially promising.

This opportunity will not wait. Recognizing the economic significance of superconductors, our foreign competitors are rapidly taking advantage of these discoveries. Japan's Science and Technology Agency has already formed a consortium of Japanese companies, universities, and government laboratories to pursue these opportunities. The U.S. research community is in a leading position as far as the fundamental aspects of this breakthrough. We must immediately build on this perhaps temporary scientific lead with an applications development program, such as that proposed by ANL, if we are to realize the potential of this breakthrough and compete successfully in the international economic arena.

Biotechnology

If biomass is to become an important component of American industrial technology--as a source of renewable energy, as a feedstock replacing petroleum, and as a prime source of chemicals and pharmaceuticals--major basic research programs are needed. These programs must include plans for transferring technology to the private sector if they are to result in new commerce. To achieve the goals of developing basic research programs relevant to industrial needs and of transferring basic research to applications, ANL has created a consortium of midwestern universities, research institutes, and corporations: "midwestern" because midwestern agriculture and agribusiness are economically and functionally distinct from those in other areas and "consortium" because the diversity of research needs and potential applications of such research suggest that no single institution could perform the required work or effectively utilize the derived results.

The Midwest Plant Biotechnology Consortium consists of 15 universities, 3 research institutes, and 38 corporations representing the following industries: agrichemicals, foods, fuels/commodity chemicals, pharmaceuticals, and seeds. Many of the participating companies either use agriproducts or may use such materials if they can serve as sources of new products or more economic sources of current products. Others produce materials involved in crop production. All of these firms would benefit if research were to result in the commercial introduction of new and more commercially attractive agricultural materials. Their interests are not only in increasing agricultural yields, but also in using that yield in new and economically important ways. This Consortium does not intend to produce greater agricultural surpluses; rather, it seeks to use such surpluses for new industrial purposes.

Argonne has discussed Consortium participation with four federal entities (U.S. Department of Agriculture, DOE, National Science Foundation, and National Institutes of Health) that support research and have established missions in the agricultural or the plant sciences. Midwestern state agencies, such as the Midwest Technology Development Institute and various organizations involved in the development of new technologies that might create new industries and new jobs within the state, have also been approached. In all cases there has been interest in the technical, organizational, and economic purposes of the Consortium.

At present, the midwestern research community has prepared some 59 preproposals, which have been submitted to the industrial participants for review with regard to their utility, potential industrial relevance, and potential for joint funding with federal entities. The preproposals involved some 28 institutions across the nation; 70 academic divisions or departments, and some 400 staff members. As these numbers suggest, the preproposals mainly represented interdisciplinary efforts that blend classical agricultural sciences with new fields like genetic engineering and molecular biology.

Industrial participants rated 33 of the 59 preproposals as of high interest and suggested that they might seek some form of joint funding on 13 of the 33. From the results of this analysis, it appears that a cross section of agribusiness feels that the preproposals describe basic research relevant to development of new technologies and new businesses. Consortium participants are now developing these 33 proposals for peer review and possible funding by appropriate federal entities.

If basic research is to improve our ability to compete, it must be of high quality and must have extensive industrial involvement. The Midwest Plant Biotechnology Consortium is certainly commensurate with these criteria. The program will require some $20 million per year over a five-year period; however, the payback to our nation, given the critical role of agriculture in the American economy, will more than justify this expenditure.

March 27, 1987

IMPROVED INDUSTRIAL COMPETITIVENESS FOR RENEWABLE ENERGY TECHNOLOGIES

Submitted to:
The Subcommittee on Energy Research & Development
of the
Senate Committee on Energy and Natural Resources
The Honorable Wendell H. Ford, Chairman

Submitted by:
Irwin Welber, President
Sandia National Laboratories
Albuquerque, NM

March 31, 1987

Improved Industrial Competitiveness for Renewable Energy Technologies

The Future Market

Renewable energy technology has been primarily considered as one component in a diversified energy supply economy targeted at maintaining the energy security of the United States. While this is a valid objective for the continuing development of renewable technologies (e.g. wind, photovoltaics, solar thermal and geothermal), an equally important (and sometimes overlooked) aspect of these advanced energy systems is their blooming economic value. The world's growth rate for remote power systems alone is currently 17% per year, and the largest portion of this growth is projected to be in the renewables area. The total remote power market, excluding small hydro, is projected to be over one gigawatt per year by 1991; this equates to a market size of several billion dollars per year for only this one segment. In addition, published plans for U.S. utility expansion in the next decade indicate a total capacity addition of over 91 gigawatts (15% of current capacity). Of this increase approximately 8 gigawatts are designated for peaking applications; this new market will undoubtedly serve as a major entry location for renewables into the U.S. grid-power market. Unfortunately, the emerging markets for these new renewable energy technologies are masked by the current U.S. perspective of greatly depressed world oil prices and the associated perception of a global energy sufficiency.

U.S. Must Lead in Technology

A fundamental rule which applies to improving industrial competitiveness in the world is: agressively pursue and attempt to capture a major share of developing new markets based on new technology. Improved competitiveness in areas of new technology such as renewable energy is crucial to the growth of U.S. industry in both domestic and export markets. Progress in world competition will be made by leading these new areas of development rather than by attempting to gain control of any mature area which is dominated by other countries.

Foreign Competition

The observation that this rule is well understood by other countries is validated by comparing the U.S. R&D investment and current market status with that of other countries. In 1983 the U.S. dominated the world market for photovoltaic power systems. By 1984 the U.S. market share had slipped to 61% with sales of 8.4 megawatts. The estimate for 1986 is only a 43% market share with sales of 7.2 megawatts. Unfortunately, this decline may continue as the rest of the world rapidly improves their technology base. Germany is currently spending as much per year on PV research as the U.S. even though they are only one fourth the size; likewise, the Japanese government is spending at least as much on photovoltaic research as is our country. Similarly, the Italian government is spending approximately $75 million per year on renewables R&D. Additional examples of the progress of foreign efforts clearly show up in the wind and solar thermal industries. In 1986 70% of the more than 2300 new wind machines sold in the U.S. were Danish, and British firms are planning significant U.S. market expansions for 1988. Likewise, essentially all of the solar thermal systems currently being sold in this country are produced by an Israeli manufacturer.

The Proper Strategy

If the U.S. expects to be a serious competitor in this emerging area of both strategic energy and economic importance, then we must invest in that future now. This investment must include developing and maintaining a superior technology base which expresses itself in terms of high efficiency, high reliability, and both low initial and operating/maintenance costs. In concert with this technology development emphasis, the renewables industry must be supported in developing a favorable marketing position and must be assisted in obtaining the very best technology available without a large financial risk.

Role of National Laboratories

Maintaining a stable, well funded research and development program is vital to improved competitiveness within the world market. Linking basic university research to industry needs through the national laboratory resources of applied R&D, systems engineering, and applications development allows the U.S. to bring a superior capability and experience to bear within the competitive environment. In this context national labs such as Sandia National Laboratories have been and will continue to be key catalysts which (1) accelerate the rate at which new technology is developed and transferred to industry, (2) help direct or focus the development process toward valuable new markets, and (3) generate spin-off technologies that may more than compensate for the total R&D investment.

Examples of Sandia Contributions

A notable example of this renewable energy technology development and transfer process at Sandia occurred in the context of the geothermal drilling research activity. The objective of the R&D program was to improve technology for drilling in the geothermal resource environment. The result of this cooperative laboratory, university, and industry association was the polycrystalline diamond compact drill bit. Although developed for geothermal uses, this bit has become the standard for use in many sedimentary formations associated with oil and gas recovery. The industry savings associated with this bit plus the value of improved resource recovery have more than paid for all of the R&D investment. The technology has been widely used by U.S. energy companies all over the world (e.g. the North Sea and the Gulf of Thailand).

Recent advances in photovoltaic systems technology at Sandia have assisted the initiation of both a water pumping system market and a water purification system market in Latin America through a cooperative effort with the World Bank. Photovoltaic cell technologies which are being developed by Sandia and SERI are promising major additions within other competitive areas. Advances in wind turbine technology will be evaluated within the next several years at the new vertical axis wind turbine test site near Amarillo, Texas; these advances will potentially halve the installed cost of wind turbines (which are currently being sold for near $1200 per kilowatt). The silvered Sol-Gel glass reflective surface developed at Sandia under the Solar Thermal program promises to revolutionize approaches to high quality, low cost solar concentrators for both terrestrial and space applications. These are but a few of the many developing technologies which promise significant competitive market advantage for U.S. industry if they receive continuing R&D support. More importantly, however, than these technologies themselves is the maintenance of a national policy of investing generously in the R&D base required to support the strategic area of renewable energy.

Summary

The U.S. has the greatest technological muscle in the world. This muscle and the institutional structure (composed of the University, National Laboratory, Industry triad) on which it resides must be adequately supported now to allow a vital competitive position in renewable energy markets tomorrow. Without this support during this early development period, the industry could be lost, and the U.S. would find itself in the undesired position of buying the technology from abroad. The Department of Energy provides the environment and the capability for developing these emerging technologies and spinning off high tech innovations to industry through its National Laboratories. This unique capacity must be protected and utilized to its full advantage.

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TESTIMONY ON THE POTENTIAL OF RENEWABLE ENERGY TECHNOLOGY WITH RECOMMENDED R&D PRIORITIES

by

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for

U.S. Senate
Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources

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INTRODUCTION

A major new study announced by Energy Secretary John Herrington on March 17, 1987, indicated a growing dependency on imported oil and warned our nation of a clear risk to national security. Just last month former secretary Donald Hodell projected gas lines again.

Renewable energy technologies provide the best hope for a balanced national energy policy featuring sensible environmental trade-offs and a sustaining society. Over time, the economics of the solar alternative will improve through research breakthroughs and more realistic consideration of the externalities, but the concern is that government policy has mostly attempted to suppress R&D in this area.

Expanded utilization of our indigenous natural resources can reduce our trade deficit, ameliorate greenhouse effect and acid rain problems, and strengthen national security baselines. We need, however, to reverse the past six year slide.

Other witnesses will elaborate on and document the above points. In this statement, focus will be placed on re-orienting research priorities to accommodate strategic national needs. The primary topics recommended for funding emphasis include:

1. Higher level of support for transportation fuels
2. Consideration of the total system of co-products
3. International cooperation with our allies

TRANSPORTATION FUELS

During the past twelve years of the federal renewable energy research program, the overwhelming emphasis has been on electricity production. While certain projects should be allowed to proceed to a logical conclusion, and related electrical topics such as energy storage should even be expanded, the fact of the matter is that electricity only accounts for 25% of the demand. The two previous energy crises were, in reality, transportation fuel based. Without a doubt, a shift in priorities should be made towards liquid (and even gaseous) fuels.

Various USDOE reports have shown that methanol from biomass is the most promising renewable option to replace gasoline. The most cost effective process is gasification of biomass, with conversion of these gases into methanol. Increased attention must be placed on how best to gasify and convert biomass into methanol. There must also be some attention paid to the methanol economy infrastructure.

The ultimate renewable transportation fuel is hydrogen, which can be combusted, cooled to the liquid form for aviation applications, stored in hydrides for ground transportation requirements and fed to fuel cells to produce electricity. The waste product is water, making hydrogen ideal from an environmental standpoint.

Hydrogen, however, is expensive to produce and liquefy. A technology status assessment completed by the Hawaii Natural Energy Institute in conjunction with the Florida Solar Energy Center for the Solar Energy Research Institute, through funding from the Department of Energy, reported on research priorities to develop a national program on hydrogen from renewable energy. A copy of Volume 1 (summary) is attached to this statement.

Hydrogen fuel is presently used for space shuttle operations. Increased need for space applications is forecast into the 1990's.

A driving motivation could well be the national aerospace plane, which will be hydrogen powered. During the next few years, a sum of $3 billion will be expended on developing the technology for this aircraft. A major concern will be the availability of cost effective hydrogen when decisions are being made to utilize this concept for military or commercial operations.

Fully one-third of the energy used in island communities goes to fuel jet liners. While the national average is not quite this high, air transportation will increase into the 21st Century, and the fuel of choice for the future will be hydrogen. It is thus today that basic research should be initiated to prepare for tomorrow. As a nation we do not want our aviation industry to go the way of Detroit.

TOTAL ENERGY/PRODUCT SYSTEMS

The price of oil is artificially supported and will widely fluctuate through the decade of the 90's until scarcity and environmental concerns will drive the cost up to levels several times that of today. It is difficult for the private sector to justify R&D expenses for energy when oil sells for $20/barrel, and further politically difficult for government to maintain a long-term rational research program at this price.

A solution to maintaining interest in a fundamentally sound energy research effort is to permit the Department of Energy to justify programs on the basis of ultimate energy and co-product revenues. At this time, there is an uneven policy on this matter.

Two renewable energy examples can be provided:

1. The Hawaii Geothermal Project is a successful example of federal government front-end support. A three megawatt powerplant is providing electricity to the grid and industrial announcements have been made for several hundred additional megawatts. However, the fluid emanating from the reservoir is saturated with silica and laced with hydrogen sulfide. Nearly 90% of the heat, furthermore, is thrown away because of Carnot cycle efficiency limitations. Fortuitous circumstances, however, have led to the silica being now coveted as a high technology coating, H_2S for industrial uses and heat for agricultural processing needs. USDOE funding has been difficult to obtain to support this type of activity. However, the potential of co-products can make geothermal energy far more economically attractive, especially during periods when oil prices are temporarily low.

2. The ocean thermal energy conversion (OTEC) program was initiated because of the promise of large amounts of baseload electricity. The Hawaiian Exclusive Economic Zone, for example, alone can many times over replace the energy equivalent of all USA oil imports. However, it has turned out that the deep cold

water can supply more than the low temperature sink. This fluid is also ten times the nutrient content of surface water and is a million times microbiologically cleaner, or pathogen-free. Aquaculture enterprises fail primarily because of aquatic diseases. Finally, the open-cycle OTEC process also supplies freshwater. The integrated OTEC concept, with electricity, freshwater, marine biopharmaceuticals, shell fish and air conditioning, is of economic interest because of the total system. There is no federal agency charged with the task to coordinate the full spectrum of these products.

It is thus recommended that the Department of Energy be charged to consider the total energy system when prioritizing R&D. This expanded mission will both serve to maintain continuity in research and bring the private sector into the program at an accelerated rate.

INTERNATIONAL COOPERATION

The USDOE has had various IEA and bi-lateral treaties with our allies to cooperate on energy R&D. There remains, however, a pervading feeling that international trips are boondoggles, and that foreigners are stealing our ideas.

There are technology areas where the USA is behind selected nations. While reverse technology transfer is difficult to negotiate, the current trade imbalance places our nation in a strong bargaining position to maximize this type of technology sharing. Increased consideration should be placed on this option.

CONCLUSION

I fear that government attitudes and policies are serving to set the stage for yet another energy crisis. This time, criticism would especially be warranted because all common sense has screamed about the need to develop alternatives to imported oil....and we have not. During this period of reprieve we have virtually eliminated transportation fuels development, reduced the effective renewable energy budget by an order of magnitude and increased oil importation.

The Senate Energy and Natural Resources Committee has a grand opportunity to bring sense and order to our national energy program. Among three foci should be increased R&D on transportation fuels, consideration of the total system of co-products and meaningful cooperation with our allies.

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